UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 31

ROCK ISLAND COUNTY SOILS

By R. S. SMITH, O. I. ELLIS, E. E. DeTURK, F. C. BAUER, and L. H. SMITH

URBANA, ILLINOIS, JUNE, 1925

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTO

It is a matter of common observation
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first essential. It is the purpose of a soil s
soil of a given area in such a manner as t
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This county soil report is one of a s
survey which, when completed, will cove
report is intended to be as nearly complet
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Appendix a general discussion of the im
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data furnished by the soil survey and t
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be of advantage to study the Appendix i

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Rock Island county was conducted, and Mr. S. V. Holt who, as leader of the field party, was in direct charge of the mapping.

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ROCK ISLAND COUNTY SOILS

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ROCK ISLAND COUNTY SOILS

By R. S. SMITH, O. I. ELLIS, E. E. De TURK, F. C. BAUER, and L. H. SMITH[1]

LOCATION AND CLIMATE OF ROCK ISLAND COUNTY

Rock Island county is situated in the northwestern part of the state, extending along the Mississippi river for about 50 miles. It is about 428 square miles in area and is divided into almost equal parts by Rock river.

Since there are no Weather Bureau records for Rock Island county for a long-continued period, the data collected at Aledo, Mercer county, are used to represent the climatic conditions in this area. The greatest range in temperature during any one year from 1902 to 1923 was 125 degrees in 1905, 1916, and 1918. The lowest temperature recorded during this period was −30°, the highest, 104°. The average date of the last killing frost in spring is April 28, the earliest in fall is October 15, giving a growing season of about 169 days.

The average annual rainfall for the period 1902 to 1922 was 33.09 inches. The rainfall by months for this period was as follows: January, 1.59 inches; February, 1.27; March, 2.13; April, 3.15; May, 4.50; June, 3.94; July, 3.54; August, 3.11; September, 4.50; October, 2.32; November, 1.93; and December, 1.31.

AGRICULTURAL PRODUCTION

Diversified farming is the rule in Rock Island county. Twenty-nine per cent of the area of the county is rough enough to be subject to serious erosion. This fact emphasizes the necessity of keeping a relatively large acreage in pasture or of using special methods to lessen erosion if the land is cultivated.

In 1919, according to the Fourteenth Census, there were 2,045 farms in Rock Island county. The average size of these farms was 119.2 acres, 87.3 acres of which were improved. Only 38.7 percent of the farms were operated by tenants, which is a slight increase over the two preceding decades.

The following figures show the acreage and production of the principal crops grown in the county. In considering these figures it should be remembered that they are for a single year only, that of 1919.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	58,508	2,529,024 bu.	43.2 bu.
Oats	22,337	663,366 bu.	29.7 bu.
Wheat	10,745	224,598 bu.	20.9 bu.
Barley	2,653	49,862 bu.	18.8 bu.
Rye	5,557	79,534 bu.	14.3 bu.
Timothy	5,781	8,309 tons	1.44 tons
Timothy and clover mixed	16,412	23,225 tons	1.42 tons
Clover	3,377	5,078 tons	1.50 tons
Alfalfa	719	2,118 tons	2.95 tons
Silage crops	2,214	19,391 tons	8.76 tons
Corn for forage	3,465	7,962 tons	2.30 tons

[1] R. S. Smith, in charge of soil survey mapping; O. I. Ellis, Assistant Chief in soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

The total value of all crops for 1919 was estimated at $6,738,106. The acreage devoted to pasture is not recorded in the Census, but a conservative estimate seems to be that 15 percent of the area of the county, or about 41,000 acres, was used for this purpose in 1923.

Livestock farming is an important industry in this county, as shown by the following figures taken from this same Census report.

Animals and Animal Products	*Number*	*Value*
Horses	10,954	$1,009,737
Mules	429	48,415
Beef cattle	15,756	927,115
Dairy cattle	15,354	1,097,107
Sheep	4,946	59,578
Swine	59,213	1,392,323
Poultry	220,082	238,695
Eggs and chickens	.....	674,746
Dairy products	.....	666,144
Wool	26,080 lbs.	13,594

The total value of livestock and livestock products was, as shown by these figures, over six million dollars in 1919.

Market gardening and dairying are highly developed near the cities. The sandy soils in the vicinity of the cities of Rock Island and Moline are well adapted to gardening and the market is good for garden products.

Fruit growing also is of considerable importance in this county. In 1919 there were about 245,000 quarts of small fruits produced and 8,900 bushels of orchard fruits. The excellent markets, together with soils adapted to fruit growing, would seem to indicate that this industry might be further developed with profit.

SOIL FORMATION

GEOLOGICAL HISTORY

One of the most important periods in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during which and immediately following, the material that later formed the mineral portion of the soils was being deposited. At that time, snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an amount that the mass pushed outward from these centers, chiefly southward, until a point was reached where the ice melted as rapidly as it advanced. In moving across the country from the far north, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even immense masses of rock. Some of these materials were carried for hundreds of miles and rubbed against surface rocks and against each other until largely ground into powder. When the limit of advance of the ice sheet was reached, the rock material carried by the ice accumulated along the front of the glacier in a broad, undulating ridge or moraine. When the ice melted more rapidly than the glacier advanced, the terminus of the glacier receded, and the material was deposited somewhat irregularly over the area previously covered. The mixture of materials deposited by the glacier is known as boulder clay, till,

glacial drift, or simply drift. The average depth of this deposit over the state of Illinois is estimated as 115 feet.

During the Glacial period at least six distinct ice advances occurred that were separated by long periods of time. They are described as follows, in the order of their occurrence:

(1) The Nebraskan, which did not touch Illinois; (2) the Kansan, which covered the western parts of Hancock and Adams counties; (3) the Illinoisan, which covered all of the state of Illinois except the northwest county (Jo Daviess), the southern part of Calhoun county, and the seven southernmost counties; (4) the Iowan, which covered a part of northern Illinois, the exact area, however, being difficult to determine because of the effect of the subsequent glaciations; (5) the early Wisconsin, which covered the northeastern part of the state as far west as Peoria and as far south as Shelbyville; (6) the late Wisconsin, which extended to the west line of McHenry county and south to the town of Milford in Iroquois county.

Previous to the ice invasion, this region generally was not well suited to agriculture because of its rough and hilly character, as is shown by borings which indicate many preglacial valleys that later were filled with drift. The general effect of the glaciers was to change the surface from hilly to gently undulating.

Rock Island county was covered by the Illinoisan glaciation, which partially leveled the region by rubbing down the hills and filling the valleys. No moraines were formed in this county. A later ice sheet, known as the Iowan glaciation, probably did not cover any portion of Rock Island county. It played an important role, however, in the formation of the soils of the county because the water from the melting ice carried large quantities of sediment and deposited it on the extensive bottom lands and terraces. Later much of this material in the form of fine sand and silt was blown on to the upland. This wind-blown deposit varies from 5 to 40 feet in thickness and is known as loess.

CHANGES IN THE RIVER SYSTEMS

The Mississippi river changed its course several times during the Glacial period. At one time, the channel was diverted to the west into Iowa near Fulton, and re-entered its present channel near Keokuk, Iowa. Later, the river followed the present valley of Meredosia slough to Rock river and thence in an eastward direction thru Henry and Bureau counties to the Illinois river. Probably, a third course of the Mississippi river was in its present channel to about Watertown, and thence east thru what is now known as Pleasant Valley.

Presumably the Rock river did not follow any of the preglacial courses of the Mississippi river, but formed a new valley leading to the present channel of the Mississippi river, thus forming the island of upland extending from Carbon Cliff to the city of Rock Island. This area is covered by a deposit of loess 40 feet in thickness at the west end, and 25 feet in thickness at the east end. The glacial drift occurs as a relatively thin sheet, the limestone bed rock being reached at a depth of 50 to 75 feet.

The island-like upland from Hampton to Meredosia slough is covered by a deposit of loess to a depth of 30 to 40 feet, beneath which there is a deposit

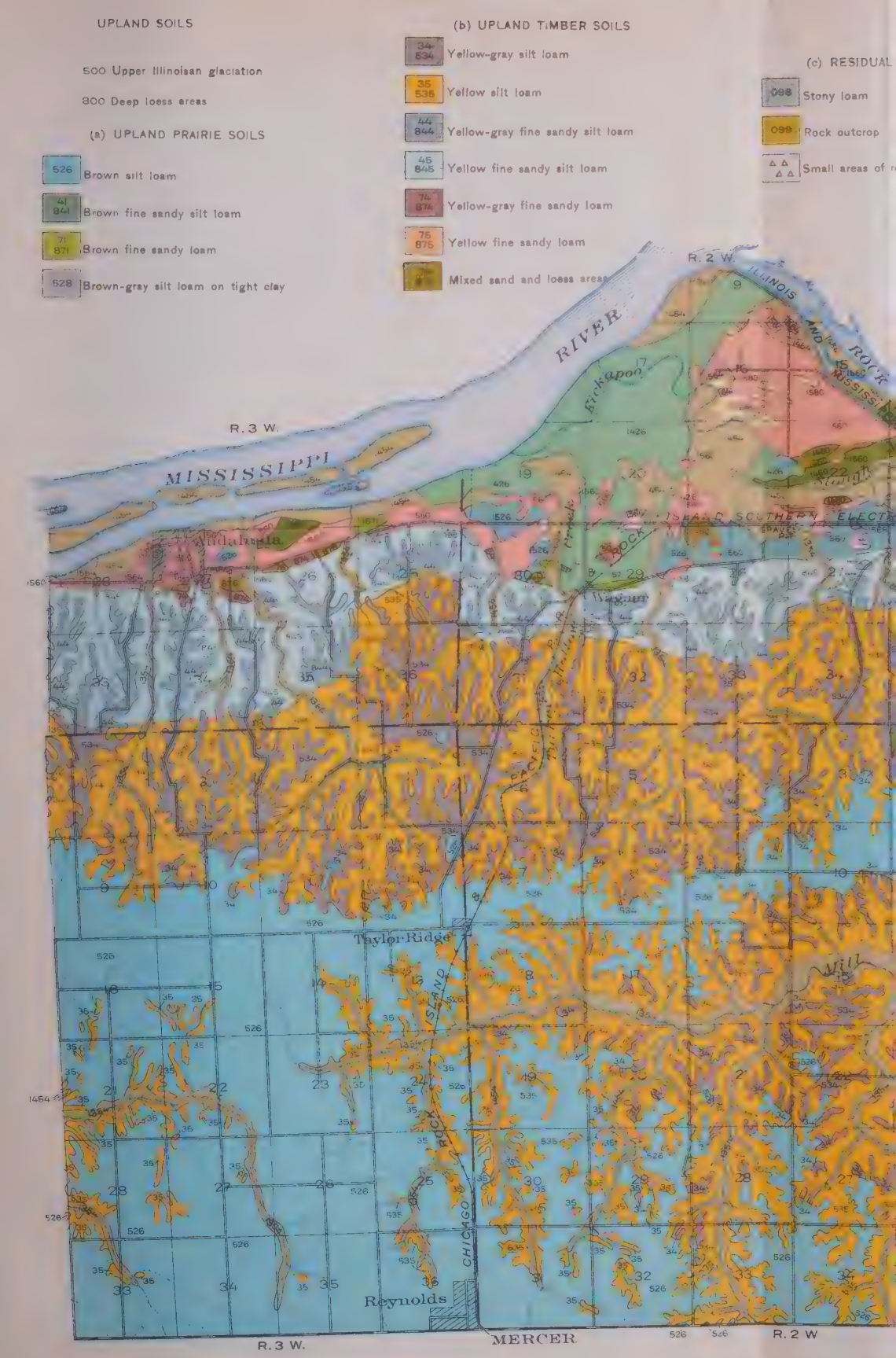
MAP SHOWING DRAINAGE SYSTEMS OF ROCK ISLAND COUNTY

of blue till extending to limestone rock at a depth of about 100 feet. The area of upland south of Rock river has a loess cap of 25 to 40 feet in thickness on the borders of the Rock and Mississippi rivers, and decreases to 15 feet in thickness at the Mercer county line. The depth to the rock varies from 50 feet at the Rock river bluffs to 150 feet at the Mercer county line.

PHYSIOGRAPHY AND DRAINAGE

The topography of Rock Island county varies from flat to undulating and rolling. In the bottom lands, the topography varies from flat to slightly undulating, the latter being due to the presence of sand ridges. Most of the terraces are undulating, altho only slightly undulating and even flat areas occur. Where the wind has opportunity to drift the sand, the topography is undulating. The upland in the prairie south and west of Rock river varies from undulating between Taylor Ridge and Edgington, to rolling in the remainder of the area where erosion has been active. In the timber areas, the topography varies from rolling to rough and broken, the slopes becoming steep near the Mississippi river. The topography of the island extending from Rock Island to Carbon Cliff varies from undulating in the Yellow-Gray Silt Loam area to rough and broken near the bluff line, with a drop of 150 or 175 feet to the terrace. The area north of Pleasant Valley in the vicinity of Port Byron varies from undulating to rolling and broken.

Practically all of the county is drained by the Mississippi and Rock rivers. There are two secondary streams, namely Copperas and Mill creeks, in the south part of the county. Nearly all the bottom land has been drained by



SOIL SURVEY MAP OF

(d) TERRACE SOILS

- 1526 Brown silt loam
- 281 1528.1 Brown silt loam on clay
- 1528 Brown-gray silt loam on tight clay
- 1560 Brown sandy loam
- 1571 Brown fine sandy loam
- 604 1560.4 Brown sandy loam on gravel
- 805 1560.5 Brown sandy loam on rock
- 88 1568 Brown-gray sandy loam on tight clay
- 64 1564 Yellow-gray sandy loam
- 641 1564.1 Yellow-gray sandy loam on clay
- 80 1580 River sand
- 8 1581 Dune sand
- 90 1590 Gravelly loam

(e) SWAMP AND BOTTOM-LAND SOILS

- 1426 Deep brown silt loam
- 1354 1454 Mixed loam
- 1460 Brown sandy loam
- 1344 1444 Yellow-gray fine sandy silt loam
- 61 1461 Black sandy loam
- 1480 River sand
- 20 1420 Black clay loam
- 1418 Drab clay
- 50 1450 Black mixed loam
- 505 1450.5 Black mixed loam on rock
- 1401 Deep peat
- 13 1413 Clayey muck
- Swamp

1300 Old swamp and Bottom Land Soils.

1400 New swamp and Bottom Land Soils

Scale

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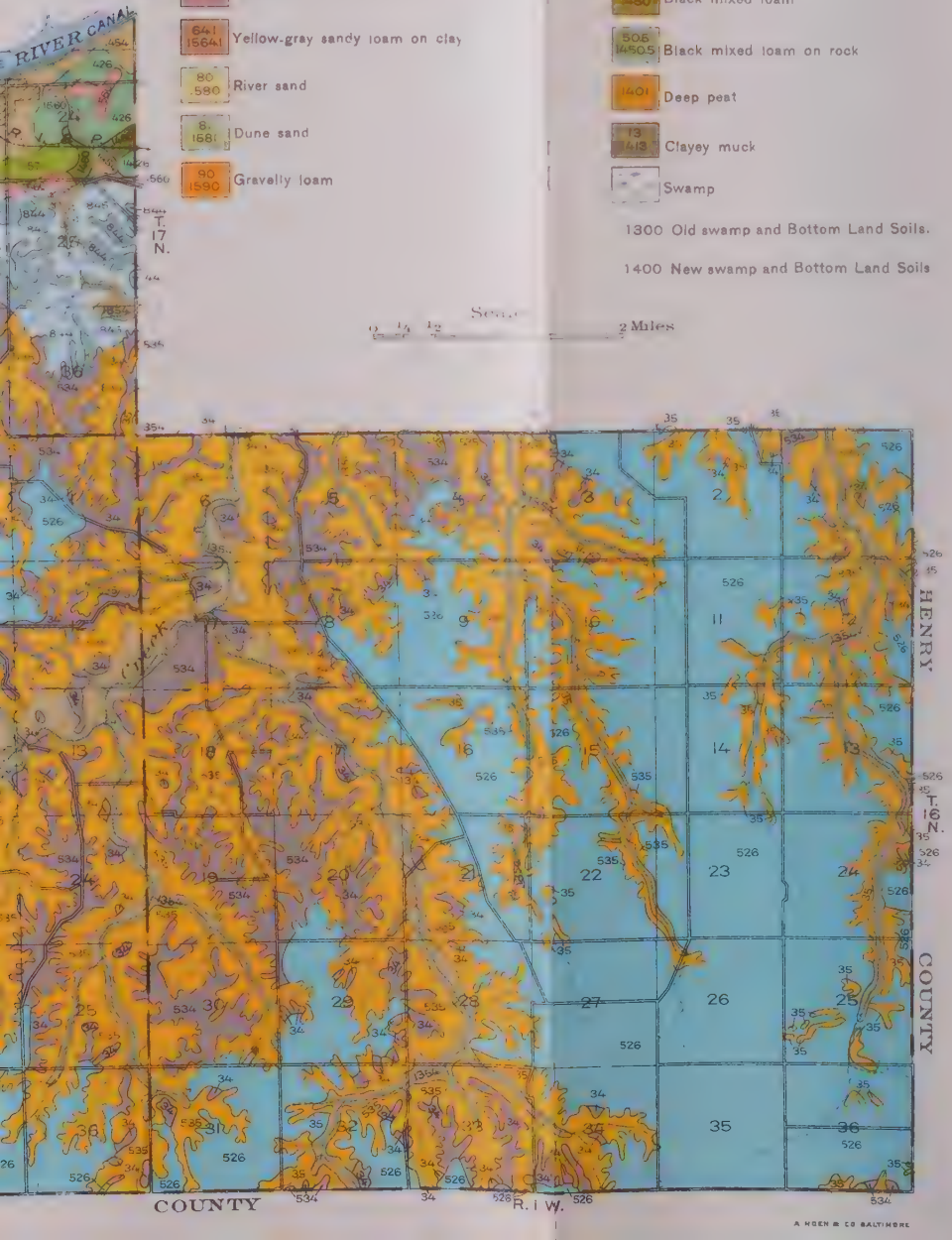

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open dredge ditches. Levees have been built along the Mississippi river and pumping stations established so as to keep down the excess water and to lower the water-table level. The Meredosia slough in the north part of the county is a sluggish stream, but has a fairly good channel. During periods of high water it serves as an overflow stream or cut-off between the Mississippi and Rock rivers. Some of the small intermittent streams in the upland disappear when they reach the terrace or bottom land. They spread over a wide expanse of area and find their way to the larger streams thru the underdrainage. Very few open ditches are required to drain readily the sandy terrace areas of excess water. The water table is usually deep enough not to hinder the growth of the crops. Some of the depressions without any outlets are poorly drained.

The altitudes of several of the more important towns of the county are as follows: Hillsdale, 577 feet; Moline, 580; Port Byron, 579; Reynolds, 800; Rock Island, 563; Taylor Ridge, 786.

SOIL GROUPS

The soils of Rock Island county are divided into five groups, as follows:

(a) *Upland Prairie Soils,* usually rich in organic matter. These areas originally were covered with wild prairie grasses, the partially decayed roots of which have been the chief source of organic matter. The upland prairie soils include some areas of recent timber growth, where certain kinds of trees have spread over the prairie, but this forestation has not been of sufficient duration to produce the characteristic timber soils. These areas of greater or less width are found along the border of most timber tracts, so that the timber actually extended a little farther than the soil would indicate.

(b) *Upland Timber Soils,* including those zones along stream courses over which forests grew for a long period of time. Timber soil contains less organic matter than prairie soil because the large roots of dead trees and the surface accumulation of leaves, twigs, and fallen trees suffered almost complete decay or were burned by forest fires. The timbered soils are divided into two groups, the undulating and the eroded.

(c) *Deep Loess,* including those soils which are sufficiently near the origin of the wind-blown material to contain considerable amounts of fine sand.

(d) *Terrace Soils,* formed by deposits from flooded streams overloaded with sediment, perhaps at the time of the melting of the glacier. Finer deposits which were later made upon the coarser material now constitutes the soil. Large quantities of sand deposited and reworked by the wind form the sand dunes.

(e) *Swamp and Bottom Lands,* which include the flood plains along the streams and some poorly drained muck and peat areas.

Table 1 gives the list of soil types in Rock Island county, the area of each in square miles, and in acres, and also the percentage of the total area. The accompanying map, shown in 4 sections, gives the location and boundary of each soil type which has been mapped in the county.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix.

TABLE 1.—SOIL TYPES OF ROCK ISLAND COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (500, 800)			
526	Brown Silt Loam	65.74	42,074	15.32
841	Brown Fine Sandy Silt Loam	5.83	3,731	1.37
871	Brown Fine Sandy Loam	.94	601	.22
528	Brown-Gray Silt Loam On Tight Clay	.10	64	.02
		72.61	46,470	16.93
	(b) Upland Timber Soils (500, 800)			
534	Yellow-Gray Silt Loam	43.64	27,930	10.18
535	Yellow Silt Loam	77.55	49,632	18.08
845	Yellow Fine Sandy Silt Loam	24.88	15,923	5.80
844	Yellow-Gray Fine Sandy Silt Loam	14.38	9,203	3.35
874	Yellow-Gray Fine Sandy Loam	25.80	16,512	6.02
875	Yellow Fine Sandy Loam	22.78	14,579	5.31
876	Mixed Sand and Loess	1.08	691	.25
		210.11	134,470	48.99
	(c) Residual Soils (000)			
098	Stony Loam	.11	70	.03
099	Rock Outcrop	.01	6	.002
		.12	76	.032
	(d) Terrace Soils (1500)			
1526	Brown Silt Loam	8.71	5,575	2.03
1526.1	Brown Silt Loam On Clay	.10	64	.02
1528	Brown-Gray Silt Loam On Tight Clay	.09	58	.02
1560	Brown Sandy Loam	29.85	19,104	6.96
1571	Brown Fine Sandy Loam	6.35	4,064	1.48
1560.4	Brown Sandy Loam On Gravel	2.47	1,581	.58
1560.5	Brown Sandy Loam On Rock	.93	595	.22
1568	Brown-Gray Sandy Loam On Tight Clay	.20	128	.05
1564	Yellow-Gray Sandy Loam	2.33	1,491	.54
1564.1	Yellow-Gray Sandy Loam On Clay	.05	32	.01
1580	River Sand	10.36	6,630	2.42
1581	Dune Sand	1.27	813	.30
1590	Gravelly Loam	.06	38	.01
		62.77	40,173	14.64
	(e) Swamp and Botton-Land Soils (1300, 1400)			
1426	Deep Brown Silt Loam	17.51	11,207	4.08
1354 1454	Mixed Loam	31.26	20,006	7.29
1460	Brown Sandy Loam	5.17	3,309	1.21
1344 1444	Yellow-Gray Fine Sandy Silt Loam	6.42	4,109	1.49
1461	Black Sandy Loam	.20	128	.05
1480	River Sand	.07	45	.02
1420	Black Clay Loam	1.46	934	.34
1415	Drab Clay	1.24	794	.29
1421	Drab Clay Loam	1.27	813	.30
1450	Black Mixed Loam	11.86	7,591	2.77
1450.5	Black Mixed Loam On Rock	.53	339	.12
1401	Deep Peat	2.61	1,670	.61
1413	Clayey Muck	.03	19	.006
		79.63	50,964	18.57
	(f) Miscellaneous			
	Water	3.14	2,010	.73
	Swamp	.27	173	.06
	Gravel Pits	.23	147	.05
		3.64	2,330	.84
	Total	428.88	274,483	100.00

LEGEND

UPLAND SOILS

500 Upper Illinoisan glaciation

800 Deep loess areas

(a) UPLAND PRAIRIE SOILS

526 Brown silt loam

841 844 Brown fine sandy silt loam

871 Brown fine sandy loam

528 Brown-gray silt loam on tight clay

(b) UPLAND TIMBER SOILS

534 Yellow-gray silt loam

535 545 Yellow silt loam

844 Yellow-gray fine sandy silt loam

845 Yellow fine sandy silt loam

874 Yellow-gray fine sandy loam

875 Yellow fine sandy loam

876 Mixed sand and loess areas

(c) RESIDUAL SOILS

098 Stony loam

099 Rock outcrop

Small areas of rock outcrop

(d) TERRACE SOILS

1526 Brown silt loam

261 1526 Brown silt loam on clay

1528 Brown-gray silt loam on tight clay

1560 Brown sandy loam

1571 Brown fine sandy loam

604 1560 Brown sandy loam on gravel

605 1560 Brown sandy loam on rock

68 1568 Brown-gray sandy loam on tight clay

64 1564 Yellow-gray sandy loam

641 1564 Yellow-gray sandy loam on clay

River sand

8 Dune sand

90 1590 Gravelly loam

(e) SWAMP AND BOTTOM-LAND SOILS

1426 Deep brown silt loam

135 1454 Mixed loam

1460 Brown sandy loam

1444 Yellow-gray fine sandy silt loam

61 1461 Black sandy loam

1480 River sand

20 1420 Black clay loam

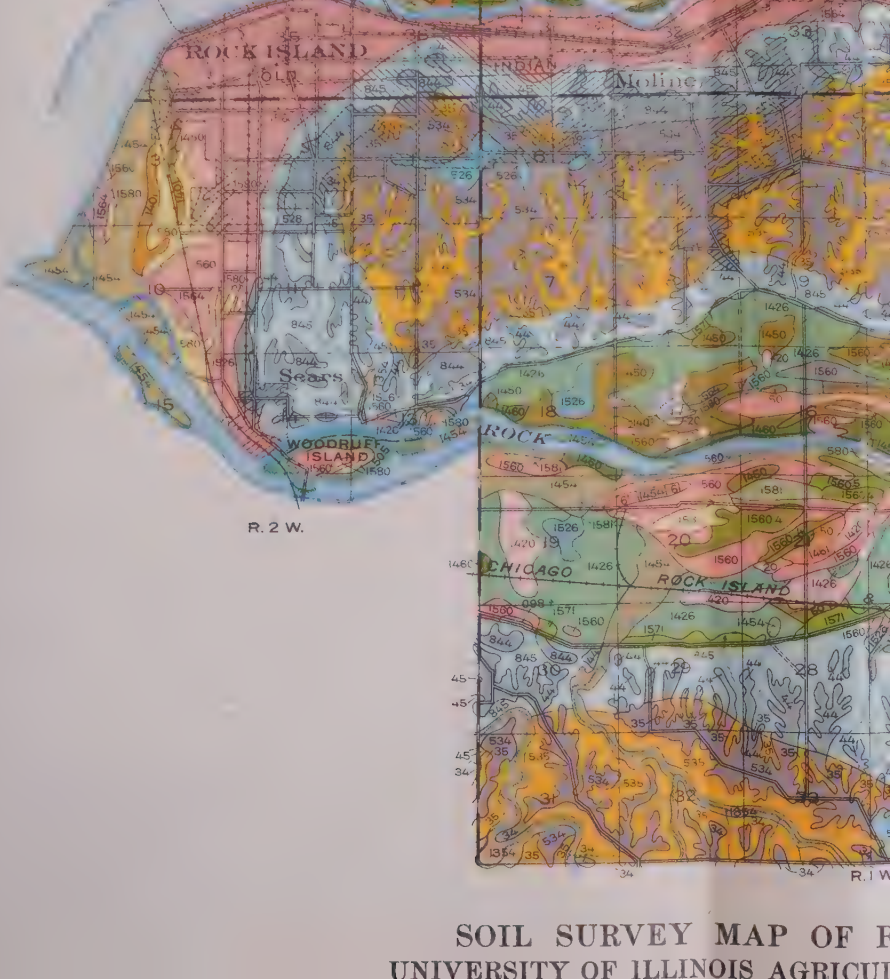
1418 Drab clay

50 1450 Black mixed loam

505 1450 Black mixed loam on rock

1401 Deep peat

13 1413 Cane [illegible]



SOIL SURVEY MAP OF R

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1300 Old swamp and Bottom Land Soils.

1400 New swamp and Bottom Land Soils

wamp

Scale

0 1/4 1/2 1 2 Miles

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K ISLAND COUNTY

RAL EXPERIMENT STATION

INVOICE OF THE ELEMENTS OF PLANT FOOD IN ROCK ISLAND COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). These sampling strata correspond approximately in the common kinds of soil to 2,000,000 pounds per acre of dry soil in the upper stratum, to two times this quantity in the middle stratum, and to three times in the lower stratum. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to in describing the soil types as surface, subsurface, and subsoil. By this system of sampling we have represented separately three zones for plant feeding. The upper, or surface layer, includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed. It should be understood, however, that the rate of liberation from their insoluble forms, a matter of at least equal importance, is governed by many factors, and is therefore not necessarily proportional to the total amounts present.

For convenience in making application of the chemical analyses, the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In this the assumption is made that for ordinary types an acre of soil to a depth of 6⅔ inches weighs, when dry, 2,000,000 pounds, exceptions being made of certain soils very high in organic matter, such as the peats and the mucks. It is understood, of course, that this value is only an approximation, but with this understanding it is believed that it will suffice for the purpose intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires to consider the information in that form.

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amounts of organic carbon (which serves as a measure of the total organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil of each type in Rock Island county.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity in different strata, no attempt is made to include in the tabulated results figures purporting to represents their averages in the respective types. In examining each soil type in the

field, however, numerous qualitative tests are made which furnish general information regarding the soil reaction, and in the discussion of the individual soil types which follow, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping and soil treatment. Therefore, it is often desirable to determine the lime requirement for a given field and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (see page 36).

In connection with Table 2, attention is called to the variation among the soil types with respect to their content of the different plant-food elements. It will be seen from the analyses that variations in the organic-carbon content of the different soils are accompanied by similar variations in the nitrogen content. The organic-carbon content is usually from 10 to 12 times that of the total nitrogen. This close relationship is explained by the well established facts that all soil organic matter contains nitrogen, and that most of the soil nitrogen (usually 98 percent or more) is present in a state of organic combination. This close relationship is also maintained in the middle and lower sampling strata. The organic matter with its nitrogen varies widely in various soils of the county. The largest amounts are found in the swamp and bottom-land soils, especially those which are peaty. Clayey Muck contains 165,075 pounds an acre of organic carbon, the largest amount found in any soil type in the county. Its corresponding nitrogen content is 14,410 pounds. The upland prairie soils are much higher in these constituents than are the timber soils, the average for the former being 51,260 pounds an acre of organic carbon, and 4,210 pounds of nitrogen, as compared to only 21,920 pounds and 2,010 pounds of the two elements, respectively, in the latter group. The relative deficiency of the timber soils in these important constituents serves to emphasize the necessity of giving particular attention to the return of organic materials to soils of this group in planning cropping systems.

Other elements are not so closely associated with each other as organic matter and nitrogen. However, there is some degree of correlation between sulfur and organic carbon. This is because a considerable, tho varying, proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of the organic matter.

The potassium content is always low in peat and muck soils, the minimum for Rock Island county being 13,150 pounds an acre in Deep Peat. With the exception of Deep Peat and Clayey Muck, the potassium does not vary widely from about 30,000 pounds. The maximum amount, as shown in the analyses, is 40,340 pounds an acre in Brown Silt Loam On Clay, Terrace.

The sandy soils furnish examples of the lowest amounts of phosphorus in the county as well as of calcium and magnesium. Dune Sand contains but 740 pounds of phosphorus, while River Sand contains only 5,200 pounds of calcium and 2,640 pounds of magnesium an acre. The comparatively small amounts of the mineral elements in the sandy soils may be due in part to the open texture which permits more rapid leaching, but is also undoubtedly due in part to the chemical composition of the parent material out of which the soil has been

LEGEND
UPLAND SOILS
500 Upper Illinoisan glaciation
800 Deep loess areas
(a) UPLAND PRAIRIE SOILS
526 Brown silt loam
44 844 Brown fine sandy silt loam
71 871 Brown fine sandy loam
528 Brown-gray silt loam on tight clay
(b) UPLAND TIMBER SOILS
34 534 Yellow-gray silt loam
35 535 Yellow silt loam
44 844 Yellow-gray fine sandy silt loam
45 845 Yellow fine sandy silt loam
74 874 Yellow-gray fine sandy loam
75 875 Yellow fine sandy loam
76 876 Mixed sand and loess areas
(c) RESIDUAL SOILS
098 Stony loam
099 Rock outcrop
Small areas of rock outcrop
(d) TERRACE SOILS
1526 Brown silt loam
261 1526 Brown silt loam on clay
1528 Brown-gray silt loam on tight clay
1560 Brown sandy loam
1571 Brown fine sandy loam
604 1560A Brown sandy loam on gravel
605 1560B Brown sandy loam on rock
68 1568 Brown-gray sandy loam on tight clay
64 1564 Yellow-gray sandy loam
641 1564A Yellow-gray sandy loam on clay
80 1580 River sand
81 1581 Dune sand
90 1590 Gravelly loam
1300 Old swamp and Bottom Land Soils.
1400 New swamp and Bottom Land Soils
R.1 E.
R.2 E.
MISSISSIPPI RIVER
T. 19 N.
T. 18 N.
Port Byron
Osborn
CHICAGO
ROCK
FERRY
SOIL SURVEY MAP OF
UNIVERSITY OF ILLINOIS AGRICU

ISLAND COUNTY

L EXPERIMENT STATION

formed. The texture of the sandy soil encourages deep penetration by the roots of crop plants and the resultant increase in the scope of the feeding zone offsets to some extent the lower concentration of the elements above mentioned in these soils.

The largest amounts of phosphorus, calcium, and magnesium are all to be found in Stony Loam, a soil occupying but 78 acres in the county, and of no great agricultural importance. These amounts are: phosphorus, 2,360 pounds, calcium, 51,180 pounds, and magnesium 29,960 pounds an acre.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded in a similar manner the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper one, it will be noted that the majority of the soil types diminish rather rapidly in organic matter and nitrogen with increasing depth, while the percentages of the other elements for the most part remain about the same and in some cases increase slightly in the lower strata. In making these comparisons, it is necessary to bear in mind that the data as given for the middle and lower sampling strata are on the basis of 4 million and 6 million pounds of soil, and should therefore be divided by two and three, respectively, thus converting them to a uniform basis of 2 million pounds, before comparing them with each other or with the data for the upper stratum.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is impossible to obtain this information exactly, especially for the deeper-rooted crops, it seems probable that practically all the feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil type, the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

A wide range of variation with respect to composition is found to occur in the sub-layers as well as in the top layers of the various soil types. The tables reveal further that there is not only this wide diversity among the different soils with respect to a given plant-food element, but that there is also a great variation with respect to the relative abundance of the various elements within a given soil type as measured by crop requirements. We may compare in this way, the two most extensive soil types in the county, namely Brown Silt Loam and Yellow Silt Loam, both upland types. The respective amounts of nitrogen in the two soils to a depth of 40 inches are 15,950 and 5,680 pounds an acre, equivalent to the nitrogen contained in the same number of bushels of corn, since a bushel of corn contains approximately a pound of nitrogen. The Brown Silt Loam thus contains nearly three times as much of this element as the Yellow Silt Loam. With regard to the phosphorus and potassium content of the two soil types, there is no significant difference. The former contains 6,210 pounds of phosphorus, which is equivalent to 36,600 bushels of corn, as compared to 5,790 pounds in the latter, equivalent to 34,100 bushels of corn. The total amounts of potassium in the two soil types, respectively, are 206,210 and 201,160 pounds, equivalent to approximately 1,085,000 bushels of corn.

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF ROCK ISLAND COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (500, 800)							
526	Brown Silt Loam	64 380	5 070	1 330	950	34 000	7 870	9 840
841	Brown Fine Sandy Silt Loam	43 340	3 720	1 260	860	32 700	6 560	9 020
871	Brown Fine Sandy Loam	46 420	4 060	1 280	760	32 080	14 520	9 220
528	Brown-Gray Silt Loam On Tight Clay	50 900	3 980	1 020	740	32 020	7 440	12 100
	Upland Timber Soils (500, 800)							
534	Yellow-Gray Silt Loam	25 790	2 330	920	630	35 330	5 090	7 640
535	Yellow Silt Loam	20 770	1 950	940	500	32 700	8 100	7 720
844	Yellow-Gray Fine Sandy Silt Loam	29 540	2 520	1 260	540	34 780	6 900	10 700
845	Yellow Fine Sandy Silt Loam	15 860	1 660	870	470	33 570	6 270	8 390
874	Yellow-Gray Fine Sandy Loam	32 510	2 850	1 000	860	32 810	5 450	8 570
875	Yellow Fine Sandy Loam	14 720	1 500	870	460	32 350	12 260	22 310
876	Mixed Sand and Loess	14 240	1 240	740	780	25 700	3 940	12 260
	Residual Soils (000)							
098	Stony Loam	85 240	7 760	2 360	1 640	22 180	29 960	51 180
099	Rock Outcrop[1]							
	Terrace Soils (1500)							
1526	Brown Silt Loam	71 520	6 060	1 580	1 540	30 300	8 960	18 180
1526.1	Brown Silt Loam On Clay	42 520	3 540	1 340	840	40 340	8 640	11 540
1528	Brown-Gray Silt Loam On Tight Clay[1]							
1560	Brown Sandy Loam	38 520	3 260	1 150	670	28 290	5 570	10 150
1571	Brown Fine Sandy Loam	37 100	2 940	1 100	900	32 540	4 860	7 320
1560.4	Brown Sandy Loam On Gravel	28 320	2 140	1 060	720	23 640	4 520	8 480
1560.5	Brown Sandy Loam On Rock	66 600	5 660	1 460	940	26 280	4 680	9 080
1568	Brown-Gray Sandy Loam On Tight Clay	49 600	4 540	1 260	980	27 600	4 040	6 340
1564	Yellow-Gray Sandy Loam	14 340	1 060	800	380	29 140	2 880	6 060
1564.1	Yellow-Gray Sandy Loam On Clay	26 780	2 240	900	480	34 800	4 900	10 380
1580	River Sand	14 880	1 160	800	720	25 220	2 640	5 200
1581	Dune Sand	14 200	920	740	700	24 160	2 860	7 560
1590	Gravelly Loam	31 040	2 540	1 060	920	24 920	5 760	9 800
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	55 390	4 700	1 450	980	30 990	8 250	13 620
1454	Mixed Loam[2]							
1460	Brown Sandy Loam	33 810	3 110	1 370	830	27 930	5 530	11 910
1444	Yellow-Gray Fine Sandy Silt Loam	27 430	2 540	1 140	780	33 350	10 870	20 900
1461	Black Sandy Loam	60 700	5 740	1 220	920	24 620	6 340	10 020
1480	River Sand[1]							
1420	Black Clay Loam[1]							
1415	Drab Clay	51 000	4 780	1 380	960	34 160	13 060	14 220
1450	Black Mixed Loam[2]							
1421	Drab Clay Loam	67 990	5 620	2 050	1 040	35 190	11 080	15 530
1450.5	Black Mixed Loam On Rock[2]							
1401	Deep Peat[3]	106 640	8 870	1 360	1 460	13 150	7 160	12 830
1413	Clayey Muck[4]	165 075	14 410	1 090	2 910	18 750	5 400	10 450

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]Not analyzed.

[2]On account of the heterogeneous character of the Mixed Loams, chemical analyses are not included for these types.

[3]Amounts reported are for 1 million pounds of Deep Peat.

[4]Amounrs reported are for 1½ million pounds of Clayey Muck.

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF ROCK ISLAND COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (500, 800)							
526	Brown Silt Loam	86 480	6 920	2 200	1 370	69 800	19 760	19 770
841	Brown Fine Sandy Silt Loam	54 360	5 000	2 440	1 240	65 680	18 880	18 280
871	Brown Fine Sandy Loam	53 280	5 160	1 960	1 200	65 560	16 840	18 160
528	Brown-Gray Silt Loam On Tight Clay	42 800	3 880	1 440	800	66 000	18 880	20 200
	Upland Timber Soils (500, 800)							
534	Yellow-Gray Silt Loam	17 520	2 190	1 700	780	71 060	16 700	14 940
535	Yellow Silt Loam	14 660	1 810	1 730	680	66 380	19 420	21 570
844	Yellow-Gray Fine Sandy Silt Loam	22 840	2 320	2 320	880	71 640	15 320	15 160
845	Yellow Fine Sandy Silt Loam	13 760	1 620	2 160	800	68 100	15 080	20 460
874	Yellow-Gray Fine Sandy Loam	29 380	2 800	1 620	1 100	68 860	15 800	17 020
875	Yellow Fine Sandy Loam	12 160	1 700	1 880	520	62 520	28 540	62 840
876	Mixed Sand and Loess	19 400	1 680	1 320	1 400	54 320	8 840	20 360
	Residual Soils (000)							
098	Stony Loam[1]							
099	Rock Outcrop[1]							
	Terrace Soils (1500)							
1526	Brown Silt Loam	85 240	7 160	2 560	2 120	62 160	17 040	28 680
1526.1	Brown Silt Loam On Clay	72 960	5 840	1 960	1 480	82 000	19 600	23 880
1528	Brown-Gray Silt Loam On Tight Clay[1]							
1560	Brown Sandy Loam	41 330	3 250	1 730	1 080	57 930	10 580	15 730
1571	Brown Fine Sandy Soil	48 360	3 880	1 920	1 080	66 480	11 000	17 760
1560.4	Brown Sandy Loam On Gravel	42 880	3 720	2 160	1 640	50 600	10 440	19 040
1560.5	Brown Sandy Loam On Rock	83 080	6 680	2 240	1 560	51 920	10 920	20 440
1568	Brown-Gray Sandy Loam On Tight Clay	25 040	2 400	1 760	1 000	64 080	9 200	12 520
1564	Yellow-Gray Sandy Loam	12 320	1 120	1 640	400	63 160	7 160	10 720
1564.1	Yellow-Gray Sandy Loam On Clay	18 040	1 840	1 520	480	73 240	12 160	14 920
1580	River Sand	26 040	1 960	1 640	1 000	48 960	6 040	12 000
1581	Dune Sand	12 160	760	1 240	1 080	45 000	5 240	14 520
1590	Gravelly Loam[1]							
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	56 780	4 720	1 980	1 400	63 220	16 600	25 560
1454	Mixed Loam[2]							
1460	Brown Sandy Loam	36 660	3 340	2 260	1 120	51 900	10 280	24 080
1444	Yellow-Gray Fine Sandy Silt Loam	41 740	3 560	2 260	1 400	66 020	19 900	49 960
1461	Black Sandy Loam	45 280	3 520	1 480	920	48 480	15 240	19 760
1480	River Sand[1]							
1420	Black Clay Loam[1]							
1415	Drab Clay	58 160	5 760	2 000	1 440	64 040	22 360	27 720
1450	Black Mixed Loam[2]							
1421	Drab Clay Loam	86 000	7 240	3 100	1 680	68 460	21 540	31 640
1450.5	Black Mixed Loam On Rock[1]							
1401	Deep Peat[3]	206 880	16 600	1 940	2 400	24 680	14 780	26 540
1413	Clayey Muck	209 600	17 280	1 480	3 360	47 680	9 520	20 080

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Not analyzed.

[2]On account of the heterogeneous character of the Mixed Loams, chemical analyses are not included for these types.

[3]Amounts reported are for 2 million pounds of Deep Peat.

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF ROCK ISLAND COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (500, 800)							
526	Brown Silt Loam	28 860	3 960	2 680	1 020	102 410	42 140	29 700
841	Brown Fine Sandy Silt Loam	28 980	3 180	3 120	1 260	97 560	34 260	36 480
871	Brown Fine Sandy Loam	29 940	3 420	2 520	1 440	102 540	30 780	26 760
528	Brown-Gray Silt Loam On Tight Clay	22 260	2 700	3 000	1 380	97 500	40 920	38 100
	Upland Timber Soils (500, 800)							
534	Yellow-Gray Silt Loam	15 610	2 140	3 400	920	102 080	35 220	27 660
535	Yelow Silt Loam	13 040	1 920	3 120	900	102 080	46 920	64 120
844	Yellow-Gray Fine Sandy Silt Loam	21 900	2 400	3 380	1 140	103 140	28 080	32 640
845	Yellow Fine Sandy Silt Loam	10 650	1 320	3 660	840	99 840	45 780	89 160
874	Yellow-Gray Fine Sandy Loam	18 300	2 270	2 970	1 470	104 280	27 120	31 080
875	Yellow Fine Sandy Loam	10 560	1 500	3 060	750	93 900	36 990	76 890
876	Mixed Sand and Loess	16 860	1 320	1 920	1 140	84 540	13 680	35 220
	Residual Soils (000)							
098	Stony Loam[1]							
099	Rock Outcrop[1]							
	Terrace Soils (1500)							
1526	Brown Silt Loam	22 560	3 060	3 540	1 680	93 420	60 720	100 680
1526.1	Brown Silt Loam On Clay	41 100	4 440	2 940	1 200	131 640	51 000	40 440
1528	Brown-Gray Silt Loam On Tight Clay[1]							
1560	Brown Sandy Loam	23 100	2 200	1 980	1 080	96 420	18 700	25 420
1571	Brown Fine Sandy Loam	28 200	2 880	2 640	1 020	100 320	18 540	26 820
1560.4	Brown Sandy Loam On Gravel[1]							
1560.5	Brown Sandy Loam On Rock[1]							
1568	Brown-Gray Sandy Loam On Tight Clay	15 360	1 380	3 000	1 320	75 540	16 500	18 960
1564	Yellow-Gray Sandy Loam	13 740	1 320	2 460	660	91 260	15 480	15 960
1564.1	Yellow-Gray Sandy Loam On Clay	19 860	2 700	3 660	900	114 060	28 140	28 380
1580	River Sand	15 300	1 500	1 800	540	72 780	10 020	20 040
1581	Dune Sand	18 180	720	1 620	1 380	68 280	9 300	26 160
1590	Gravelly Loam[1]							
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	29 610	3 060	2 610	990	99 060	28 680	38 040
1454	Mixed Loam[2]							
1460	Brown Sandy Loam	28 230	2 190	2 820	1 230	75 660	14 610	30 990
1444	Yellow-Gray Fine Sandy Silt Loam	76 620	6 510	4 170	1 500	96 840	36 060	82 080
1461	Black Sandy Loam	35 460	2 580	1 620	1 080	73 200	24 720	28 500
1480	River Sand[1]							
1420	Black Clay Loam[1]							
1415	Drab Clay	50 040	4 920	2 940	780	96 000	33 240	39 060
1450	Black Mixed Loam[2]							
1421	Drab Clay Loam	61 740	4 800	4 230	1 980	103 230	30 600	39 750
1450.5	Black Mixed Loam On Rock[1]							
1401	Deep Peat[3]	154 350	10 020	1 680	2 160	13 830	26 640	32 640
1413	Clayey Muck	29 970	2 520	1 080	1 560	67 200	11 160	19 020

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Not analyzed.

[2]On account of the heterogeneous character of the Mixed Loams, chemical analyses are not included for these types.

[3]Amounts reported are for 3 million pounds of Deep Peat.

These two soil types vary widely in calcium content, the amounts contained to a depth of 40 inches being 59,310 pounds in Brown Silt Loam and 93,410 pounds in Yellow Silt Loam. The relative amount of calcium is not of so great importance directly in connection with the corn crop as it is with respect to legumes. Since a ton of red clover hay contains approximately 29 pounds of calcium, these two soils contain as much calcium as would be removed in 2,040 and 3,220 tons of red clover, respectively. Three other soil types contain exceptionally large quantities of calcium. In all cases it is due to the presence of calcium carbonate (limestone) in the subsoil, the third sampling stratum being the only stratum exhibiting a high calcium content. These types are Yellow Fine Sandy Loam, Yellow Fine Sandy Silt Loam, and Brown Silt Loam, Terrace. In each case only one of the samples collected for the type contains calcium carbonate and then only in the lower stratum sampled. The other areas no doubt contain calcium carbonate, but it occurs below the 40 inch depth reached in sampling, and is therefore of no very great value to growing crops.

These statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration, aside from merely the amount of plant-food elements present in the soil. Much depends upon the nature of the crops to be grown as to their utilization of plant-food materials, and much depends upon the condition of the plant-food substance themselves as to their availability. Finally, in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon, and in this way these chemical data contribute fundamental information for the intelligent planning in a broad way of systems of soil management for conserving and improving the fertility of the land.

DESCRIPTION OF SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Rock Island county occupy 72.61 square miles, or 16.91 percent of the area of the county. Most of the prairie soils are found south of Rock river. However, small areas of prairie soils are found on the island-like tract of upland between Meredosia slough and Hampton, and a few areas on the upland between Rock Island and Carbon Cliff. The dark color of the prairie soils is due to the accumulation of organic matter which is derived, very largely, from the fibrous roots of the prairie grasses. The network of grass roots was protected from rapid and complete decay because of the exclusion of oxygen by the covering of fine moist soil and mats of vegetative material of old grass and leaves. On the native prairies, the stems and leaves were usually burned in part by prairie fires or disappeared in part by decay. This surface accumulation, which was constantly renewed, added but little organic matter to the soil directly, but the decay of the prairie-grass roots was retarded considerably by it.

Brown Silt Loam (526)

Brown Silt Loam covers an area of 65.74 square miles, or 15.32 percent of the county. In topography, it varies from undulating to rolling. The undulating areas occur south of Rock river from the vicinity of Edgington to Taylor Ridge. In portions of the Brown Silt Loam area, erosion has been so active as to remove the surface soil and expose the subsoil. These areas were mapped as Yellow Silt Loam. It is a common practice to leave small gullies and places which erode easily in permanent grass, thus controlling the difficulty. The Brown Silt Loam in the north part of the county, east of Port Byron, has an appreciable amount of fine sand in the surface soil, owing to its nearness to the sandy areas to the west.

The surface soil, which is about 8 inches in depth, is a silt loam varying in color from brown to grayish brown and in some cases an appreciable amount of fine sand is found. The subsurface, extending from 8 to 19 or 20 inches in depth, varies from a drabbish brown to a yellowish brown silt loam, the former occurring where the surface has a gray cast. The upper portion of the subsoil, 19 to 32 inches, varies from a plastic, compact, drabbish gray or drabbish yellow, silty clay loam to a yellow silt loam, splotched with bright yellow iron concretions. The lower part, below 32 inches, is usually a friable, mottled, yellow silt loam, splotched with bright yellowish red iron concretions.

Management.—The tests made indicate that this type is not strongly acid. Much of it will grow red clover fairly well without the addition of limestone, but the successful growth of alfalfa or sweet clover usually requires the application of 2 or 3 tons of limestone an acre. The need for limestone and the amount required should be determined in detail for each field, either with the assistance of the county farm adviser or thru correspondence with the Experiment Station.

The successful management of this type requires that adequate provision be made for the maintenance of the nitrogen and organic matter thru the use of farm manure, crop residues, and clover, preferably sweet clover. The first step in carrying out this program is the application of limestone, if needed.

The portions of this type which have a gray cast are very similar to the soil upon which the Aledo experiment field is located. A discussion of the results from this field will be found in the Supplement to this Report (see page 54). It will be noted that comparisons are being made in the phosphate experiments between acid phosphate, steamed bone meal, basic slag, and rock phosphate, both with and without lime.

While the information available regarding the phosphate fertilization of soil similar to that upon which the Aledo field is located is not so conclusive as we would wish, yet all of the information available indicates that if the nitrogen and organic matter are maintained by the use of clovers, manure, and crop residues, rock phosphate and basic slag may be used at a good profit.

The reader is referred to the Supplement to this Report for the results of field experiments on Brown Silt Loam at Kewanee, Galesburg, and Urbana, and asked to give the problem of phosphate fertilization careful study, since it is much easier to maintain the crop-producing power of a soil than it is to restore it after the yields have begun to decline.

Brown Fine Sandy Silt Loam (841)

Brown Fine Sandy Silt Loam covers an area of about six square miles, or 1.37 percent of the county. This is one of the loess soils and is found in the north part of the county between Meredosia slough and the Mississippi river. A few areas occur also in the southwestern part of the county. The undulating to rolling topography of this type was caused by the action of the wind in the formation of sand ridges.

The surface soil, which is about 8 inches in depth, is a brown, fine sandy silt loam. The subsurface to a depth of 20 inches is a yellowish brown, fine sandy silt loam. The upper 14 inches of the subsoil is a friable, yellow, fine sandy silt loam, while below 34 inches, it is a light reddish yellow, fine sandy loam.

Management.—Brown Fine Sandy Silt Loam is well adapted to the growth of alfalfa, but since no carbonates occur within 40 inches of the surface, it is very necessary to apply limestone before seeding either alfalfa or sweet clover. The assistance of the county farm adviser or Experiment Station should be secured in determining the proper amount of limestone to use. The friable nature of this type favors deep root penetration and it seems unlikely that phosphate fertilization will pay unless it be in the case of wheat. After adequate provision has been made for supplying nitrogen and organic matter by the growth of clovers and use of farm manure and crop residues, the trial of rock phosphate at the rate of about 1,000 pounds an acre, acid phosphate at the rate of about 300 pounds per acre, or basic slag at the rate of about 500 pounds an acre for wheat is advised. The rock phosphate should be applied prior to plowing for wheat and the other materials after plowing and worked into the soil as the seed bed is being prepared.

Brown Fine Sandy Loam (871)

Brown Fine Sandy Loam occupies 601 acres, or .22 percent of the county. Nearly all the areas are in the western part of the county in the timbered deep loess area. The type is of a rolling topography owing to the action of the wind that has deposited the fine sandy loam in dune-like formation. Most of this land has been left in permanent pasture.

The surface soil, which is about 8 inches in depth, is a brown fine sandy loam, mealy in texture. The subsurface, 8 to 21 inches, is a brownish yellow, fine sandy loam. The subsoil in the upper 14 or 15 inches is a rather heavy, fairly compact, yellow, sandy silt loam, and in the lower part, a yellow silt loam with an appreciable amount of fine sand.

Management.—The recommendations made for the management of the preceding type, Brown Fine Sandy Silt Loam, apply also to this type.

Brown-Gray Silt Loam On Tight Clay (528)

There are only about 64 acres of Brown-Gray Silt Loam On Tight Clay, Upland, mapped in Rock Island county.

The surface soil, extending to a depth of 7 or 8 inches, is a brown silt loam with a gray cast. From a depth of 8 inches to 16 or 18 inches, the subsurface is a floury to gritty, gray silt loam mottled with brown. The upper part of the

subsoil is a drab to grayish drab clay, tough and plastic, and very impervious to the penetration of water. The lower part of the subsoil, below 32 inches, is a somewhat friable, sandy, drabbish yellow, clay loam to silty clay loam.

Management.—This type is strongly acid and is not well supplied with nitrogen and organic matter. Because of the impervious subsoil, surface drainage must be depended on for the removal of excess water.

(b) UPLAND TIMBER SOILS

The upland timber soils are found well distributed thruout the county, adjacent to the streams. Usually, they are characterized by a yellow or yellowish gray color, owing to the low organic-matter content. This lack of organic matter has been caused by the long-continued growth of forest trees. As the forests invaded the prairies, the following effects were produced: the shading of the trees prevented the growth of grasses, the roots of which are mainly responsible for the large amount of organic matter in the prairie soils; and the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed or were destroyed by forest fires. The timbered soils cover about 210 square miles, or practically half the area of the county.

Yellow-Gray Silt Loam (534)

Yellow-Gray Silt Loam occupies the flat to undulating areas of timber soil near the streams. It will be noted on the map that near the headwaters of the small streams Brown Silt Loam occurs adjacent to the Yellow Silt Loam. This is an unusual condition, probably brought about by the circumstance that headwater erosion has been so rapid that there has not been time for the usual timber growth. This type occupies 43.64 square miles, or 10.18 percent of the area of the county.

The surface soil, which is about 5 inches in depth, varies from a brownish yellow to either a brownish or a yellowish gray, silt loam. The texture of this type is coarser near the deep loess, owing to the action of the wind in distributing fine sand over it. The subsurface, which extends to a depth of 18 or 19 inches, varies from a mottled, light yellow to yellow, silt loam. The upper stratum of the subsoil is about 10 inches thick and varies from a compact, mottled, light yellow silt loam to a compact, mottled, yellow, silty clay loam. The lower stratum of the subsoil varies from a mottled, light to golden yellow, friable silt loam and contains many yellow and red iron concretions.

Management.—This type is usually acid in the surface, tho not strongly so, and is nearly always more acid in the subsurface and subsoil than in the surface. The degree of acidity indicates that an application of 2 or 3 tons of limestone an acre is necessary for the growth of alfalfa or sweet clover. Red clover can be grown on portions of the type without the addition of limestone. Before applying limestone, the assistance of the county farm adviser or of the Experiment Station should be secured to determine the exact rate of application.

This soil is very low in organic matter and runs together badly after rains. The first step in its improvement is the application of the right amount of limestone, and the second, the growth of clover, preferably sweet clover. It is an

excellent plan to pasture the sweet clover the fall of the first year and turn it under for corn the spring of the second year. The phosphorus content of this soil is not high. It is suggested, therefore, that after the nitrogen and organic-matter deficiency has been met, at least in part, trial be made of the various phosphates.

Yellow Silt Loam (535)

Yellow Silt Loam covers 77.55 square miles, or about 18 percent of the area of the county. As mapped, it is the eroded portion of the timber soils from which much or all of the surface soil has been removed by washing. The topography of the type varies from strongly undulating to rough and broken. The slopes are longer and steeper near the river bluffs than they are farther back. The timber has been removed from practically the entire area. Portions of it have been allowed to grow up in underbrush and are of no value as sources of timber and of little value as pasture. Other portions are being farmed, frequently with disastrous results because of washing. In places where grass has been allowed to grow for some time, a shallow, yellowish brown, surface soil has been developed.

The exact character of this type varies greatly because of differences in vegetation and amount of washing. The surface to a depth of 4 or 5 inches is usually a grayish yellow or brownish yellow silt loam. The subsurface to a depth of 8 to 15 inches is a yellow silt loam. The subsoil is usually a somewhat plastic, yellow, silty clay loam. Till usually occurs at a depth of 4 to 10 feet and a stratum of yellowish red, sandy silt loam from 10 to 14 inches in thickness frequently occurs on top of the till.

Management.—This type should, for the most part, be used for pasture, orcharding, or timber production. The less steep slopes may be farmed successfully if special precautions are taken to prevent washing. This may be done by keeping some vegetation on the land as much of the time as possible, practicing contour tillage, terracing, and seeding the land to grass for a few years as soon as a tendency to wash becomes pronounced.

This soil is but slightly acid and carbonates commonly, tho not always, occur within one or two feet below the surface of the till. In no instances were carbonates found above the till. Alfalfa can be grown successfully on the less steep slopes of this type after a moderate application of limestone has been made. The exact rate of application of limestone should be determined with the assistance of the county farm adviser or thru correspondence with the Experiment Station. Good use may be made of much of this land as sweet clover pasture after limestone has been applied. No treatment other than the application of limestone and the provision for increasing the nitrogen and organic-matter contents of the soil is advised. (See account of Vienna field experiments, page 62.)

Yellow Fine Sandy Silt Loam (845)

Yellow Fine Sandy Silt Loam covers an area of 22.78 square miles, or 5.31 percent of the area of the county. Most of the timber has been removed and cultivated crops have been grown on the eroded hillsides until some of the areas have been abandoned because of erosion, or are producing very little. In some places

on this type, particularly in the western part of the county, wind action has been effective in forming sand dunes.

The surface soil, which is about 4 inches in depth, varies from a brownish yellow or yellowish gray to a yellow fine sandy silt loam. The subsurface and subsoil are a yellow fine sandy silt loam. In a few instances, glacial till was found 10 to 12 feet below the surface.

Management.—This type should ordinarily not be used for growing the grain crops. The more gentle slopes may be so used if proper precautions are taken to prevent erosion. Much of the area contains carbonates and, when such is the case no limestone is needed to grow alfalfa or sweet clover; in fact the latter is found growing wild on some portions of the area. Good use may be made of much of the type by growing alfalfa on the less steep slopes and sweet clover on those which are of intermediate steepness. Portions of the area may be used for orcharding and other portions should be used for timber production.

Yellow-Gray Fine Sandy Silt Loam (844)

Yellow-Gray Fine Sandy Silt Loam covers an area of 14.38 square miles, or 3.35 percent of the area of the county. This type is found on the upland immediately adjoining the bottom land. In topography it is the same as Yellow-Gray Silt Loam described on page 16.

The surface soil, which is about 6 inches in depth, varies from a brownish yellow to a yellowish gray, fine sandy silt loam. The subsurface, extending to a depth of about 18 inches, is a mottled, yellow, fine sandy silt loam. The subsoil occurs in two strata. The upper, to a depth of about 32 inches, is fairly compact and varies from a mottled, yellow, fine sandy silt loam to a yellow, silty clay loam splotched with bright red concretions. The lower part, below 32 inches, is strongly mottled and varies from a light yellow to golden yellow, fine sandy silt loam, and contains bright yellowish red iron concretions.

Management.—This type is very similar to Yellow-Gray Silt Loam (534) excepting that it does not run together so badly after rains, is somewhat easier to work, and is usually slightly less acid. It is very low in organic matter, however, and requires the same management as suggested for Yellow-Gray Silt Loam to increase its productivity (see page 16).

Yellow-Gray Fine Sandy Loam (874)

Yellow-Gray Fine Sandy Loam is one of the loessial soils found adjacent to the Mississippi bottoms. It is undulating in topography and occupies the same relative position with respect to adjoining soil types as does Yellow-Gray Silt Loam. It covers 25.80 square miles, or about 6 percent of the area of the county.

The surface, which is about 6 or 8 inches in depth, varies from a brownish yellow to a yellowish gray, fine sandy loam. The subsurface, extending to a depth of about 19 inches, varies from a friable, yellowish brown to golden yellow, fine sandy loam. The upper 12 to 15 inches of the subsoil varies from a some-

what compact, yellow silt loam to a yellow sandy silt loam. The lower part varies from a mottled, yellow, fine sandy silt loam to a mottled, yellow, fine sandy loam.

Management.—This type is more open in structure than Yellow-Gray Silt Loam (534) and runs together less after rains. Its limestone requirement is about the same as that of Yellow-Gray Silt Loam, and it should be managed in the same way. It is an excellent alfalfa soil because of its open structure and also because carbonates usually occur within 40 or 50 inches of the surface, thus making it unnecessary to add as much limestone as in the case of soils which have been leached to a greater depth.

Yellow Fine Sandy Loam (875)

Yellow Fine Sandy Loam, as mapped, consists of the eroded area of loess near the bluffs. Deep gullies have been formed by long continued erosion. The timber has been largely cut off and the land farmed until much of it can no longer be used profitably for grain crops. The type occupies 22.48 square miles, or 5.31 percent of the county. There is usually no true surface or subsurface present because for the most part they have been eroded away. A thin surface soil, however, has been developed over small areas where the growth of grass has protected the soil from erosion. The soil to a depth of 40 inches is a yellow, fine sandy loam, open and easily penetrated by roots.

Management.—This type, because of its rough topography, should be used for pasture, orchard, or timber. The depth to carbonates varies greatly. In places, strong effervescence with acid occurs at one foot below the surface, while in others no effervescence occurs to a depth of 25 feet. This soil will grow good alfalfa on the more gentle slopes after limestone has been applied. If either alfalfa or sweet clover is to be grown, the amount of limestone necessary should be determined with the assistance of the county farm adviser or of the Experiment Station.

Mixed Sand and Loess (876)

Small areas occur in the northern and western parts of the county in which the wind has deposited strata of different texture. Erosion has subsequently exposed these strata in places so that a great variety of soils is formed. The areas of the various soils are so small that they cannot be mapped separately and they have therefore been grouped together and called Mixed Sand and Loess. The surface varies from brown to yellow in color and from a fine sandy loam to sand in texture. The subsurface varies in like manner. The subsoil, starting at a depth of about 18 inches, is usually a yellow sand.

Management.—This soil is used chiefly for pasture. The lower brown-colored areas are excellent for gardening or for watermelon production. Probably one of the best uses which can be made of these areas is to apply sufficient lime to grow sweet clover for pasture. After this crop has been grown a few years, alfalfa probably can be successfully grown.

(c) RESIDUAL SOILS

Stony Loam (098)

Stony Loam is found in a few scattering areas lying mainly at the southeast of Cordova. It occupies only 70 acres and is of no agricultural importance.

Rock Outcrop (099)

Rock outcrop occurs as exposures of rock and the character of the rock determines its value. There are several quarries near Moline and one in the eastern part of the county where limestone is being taken out. There are other exposures of shale and cherty limestone, neither of which has any agricultural value.

(d) TERRACE SOILS

Large areas of terrace soils occur in Rock Island county because of the changes which have occurred in the river systems. They were formed by overloaded and flooded streams which deposited an immense amount of material in the old channels. Later as the streams diminished in size or cut their channels deeper, new bottoms were developed, leaving the old flood plains above overflow, thus forming terraces.

These terrace formations which were built up, for the most part, during and immediately following the Glacial period, were later covered to varying depths with wind-blown material from which the present soils were formed.

Brown Silt Loam (1526)

Brown Silt Loam, Terrace, occurs for the most part in Pleasant Valley and along Rock river. In many places, fine sandy outwash from the bluffs has been deposited upon the Brown Silt Loam. The type covers an area of 8.71 square miles, or 2.05 percent of the area of the county. Drainage is usually good altho small areas occur near the bluffs where seepage water causes wet spots. Many small intermittent streams deposit their water over the surface without following any definite channel, causing a temporary water-logged condition.

The surface soil, extending to an average depth of 8 inches, varies from a brown silt loam to a brown, fine sandy silt loam. The subsurface, extending from 8 to 20 inches, varies from a light brown to a yellowish brown, fine sandy silt loam. The subsoil below 20 inches is usually in two parts; the upper, usually 14 or 15 inches in thickness, varies from a yellow, fine sandy silt loam to a somewhat compact, grayish yellow, fine sandy loam; the lower varies from a somewhat plastic, drab clay loam to a yellowish gray, fine sandy silt loam splotched with yellowish red iron concretions.

Management.—A large proportion of this type is not acid and in no case was it found to be more than slightly acid. It is a productive, easily worked soil and is adapted to any of the general farm crops. The more sandy portions near the bluffs are well adapted to trucking. The most important consideration in the management of this type is the provision for maintaining an adequate nitrogen supply. This can be done only by growing clover at regular intervals and plowing down a portion of the total growth. Sweet clover is unexcelled as a source of nitrogen and can be used to good advantage as a combination pasture

and green manure crop by pasturing it the fall of the first year and plowing it in for corn the spring of the second year. No experimental information is available upon which to base recommendations for the fertilizer treatment of this type. It is suggested if any purchased fertilizer is used, that it be used in a limited way until its value or lack of value has been demonstrated. In no case should any fertilizer other than one of the phosphates be used excepting for truck crops.

Brown Silt Loam On Clay (1526.1)

Brown Silt Loam On Clay occurs in a few scattered areas in the northern part of the county and covers a total of only 64 acres.

The surface soil, extending to 8 inches in depth, is a heavy brown silt loam. The subsurface, 8 to 16 inches, is a light brown silt loam mixed with some yellowish red sand. The subsoil in the upper 17 inches is a tough, brick-red clay. In the lower part, it varies from a brick-red sandy clay loam to a sandy silt loam.

Management.—About 2 tons of limestone an acre should be applied to this type and sweet clover grown to be plowed down the spring of the second year for corn. Surface drainage is necessary as the upper stratum of the subsoil is too heavy and impervious to permit tile drainage.

Brown-Gray Silt Loam On Tight Clay (1528)

Brown-Gray Silt Loam On Tight Clay occurs in small isolated areas thruout the terrace. It is located in pockets or depressions that are not well drained. It covers an area of only 54 acres.

The surface soil, which is about 4 inches in depth, is a grayish brown silt loam. The subsurface, extending to 14 inches in depth, is a gray silt loam splotched with a few yellow iron concretions. The subsoil is found in two distinct parts. The upper, extending to a depth of 34 inches, is a very sticky and compact gray clay, having some yellow clay streaks. The lower part, below 34 inches, is a friable, grayish drab clay loam, splotched with some red iron concretions.

Management.—This type is strongly acid and should receive about 4 tons of limestone an acre. Surface drainage must be depended on and sweet clover should be grown frequently.

Brown Sandy Loam (1560)

Brown Sandy Loam, Terrace, occurs in scattered areas thruout the Rock river and Mississippi river terraces, altho most of it is found along Rock river. The type covers 29.85 square miles, or about 7 percent of the area of the county. The sand content of this type varies from place to place. In the vicinity of River Sand (1580), the Brown Sandy Loam is underlain with sand. Near the bluffs, the fine sand content is high, owing to outwash material having been deposited at the base of the slopes.

The surface soil, which is about 8 or 10 inches in depth, is a brown sandy loam, varying from medium to coarse in texture. The subsurface extending to about 18 inches, is a brown sand. The subsoil is a yellow sand.

Management.—This type is somewhat acid, tho not strongly so. It does not stand drouth so well as soils having a less coarse subsoil, and corn is likely to suffer from lack of moisture unless the rainfall is well distributed thruout the growing season. The small grains and soybeans are well adapted to this type. The frequent plowing down of leguminous green manure crops is advised, and also the use of all manure available.

Brown Fine Sandy Loam (1571)

Brown Fine Sandy Loam, Terrace, occurs in small scattered areas thruout the Mississippi and Rock river terraces. Most of the areas seem to have been formed by outwash from the bluffs. The type is not uniform because of the way in which it has been formed. It occupies 6.35 square miles, or 1.48 percent of the area of the county.

The surface soil, extending to about 9 inches in depth, is a light brown to chocolate brown, fine sandy loam. The subsurface is a light brown, fine sandy loam. The upper part of the subsoil is a bright yellow, fine sandy loam, while the lower part below 36 inches is a slightly compact, yellow, sandy silt loam.

Management.—This type is only slightly acid in the surface but frequently shows medium acidity in the subsurface and subsoil. It is a productive, easily-worked soil and the friability of the subsoil favors deep root penetration. The nitrogen supply should be provided for by growing clovers and turning in a portion of the crop. No definite fertilizer treatment is recommended; however, it would be an excellent plan to determine by trial whether one of the phosphates might not be used at a profit for wheat.

Brown Sandy Loam On Gravel (1560.4)

Brown Sandy Loam On Gravel covers only 2.47 square miles, or about .58 percent of the area of the county. It occurs as small areas scattered thruout the terraces. It is slightly undulating in topography and is very sandy for the type. The gravel is usually near enough to the surface to be detrimental because of its interference with the moisture supply for the growing crop.

The surface, to about 8 inches in depth, is a coarse-grained, brown sandy loam. The subsurface, from 8 to 18 inches, is a light brown sandy loam. The subsoil, which on the average is about 6 or 7 inches in thickness, rests on the gravel layer or bed and is a yellow sand. The gravel is composed of well-rounded, small and medium-sized pebbles and stones.

Management.—This type is not adapted to the general farm crops because of its drouthy nature. It is somewhat acid and is not well supplied with organic matter.

Brown Sandy Loam On Rock (1560.5)

Brown Sandy Loam On Rock is a type of little importance. It covers less than one square mile and is found chiefly on Rock and Sylvan islands.

The surface soil, which extends to about 8 inches in depth, is a coarse-grained, brown sandy loam. The subsurface is a coarse-grained, yellowish brown sand and rests on limestone rock, which occurs at a depth of 20 to 22 inches below the surface.

This type is used chiefly for pasture and is suited to nothing else. Efforts have been made to grow clovers but with little success because of the drouthy nature of the soil.

Brown-Gray Sandy Loam On Tight Clay (1568)

Brown-Gray Sandy Loam On Tight Clay covers only about two-tenths of a square mile, or 128 acres. It is flat and usually found at a lower level than the adjacent soil types.

The surface, to a depth of 4 inches, is a grayish brown sandy loam. The subsurface, extending to a depth of about 19 inches, varies from a brownish gray sandy loam to a gray sand. The subsoil is in two distinct strata; the upper stratum, which is 10 or 11 inches in thickness, is a plastic, very compact, gray sandy clay, with a few yellow splotches; the lower is a friable, brick-red, sandy silt loam.

Management.—Provision for good surface drainage, the addition of limestone, and the growing of clovers, preferably sweet clover, are essentials in the management of this type.

Yellow-Gray Sandy Loam (1564)

Yellow-Gray Sandy Loam is undulating in topography and is found in small, scattering areas in the Rock river terrace.

The surface soil, extending to about 5 inches in depth, varies from a brownish yellow sandy loam to a yellowish gray fine sandy loam, the latter occurring near the bluffs. The subsurface, 5 to 22 inches, varies from a yellow sandy silt loam to a yellow sand. The subsoil is in two fairly distinct parts; the upper, which is about 8 inches in thickness, varies from a yellow silt loam to a fairly compact, red sandy clay; the lower part, below 30 inches, varies from a yellow sandy silt loam to a brick-red, coarse-grained sand.

Management.—This type is very similar to Yellow-Gray Fine Sandy Loam (874), except that most of the area is coarser in texture and carbonates do not occur within the 50-inch section. The reader is referred to the discussion of the management of Yellow-Gray Fine Sandy Loam (874) and Yellow-Gray Silt Loam (534) for suggestions regarding the management of this type.

Yellow-Gray Sandy Loam On Clay (1564.1)

Yellow-Gray Sandy Loam On Clay is found in only one area of 32 acres located along the Mississippi river north of Port Byron.

The surface soil, which is about 7 inches in depth, varies from brownish yellow to a grayish yellow sandy loam. The subsurface, extending to about 19 inches in depth, is a grayish red sandy loam. The subsoil is a sticky, compact red clay with some sand and gravelly material mixed with clay making the lower part somewhat gritty. The area is in timber and pasture.

River Sand (1580)

Most of the River Sand, Terrace, is found in the northern part of the county, adjacent to Whiteside county. It occupies 10.36 square miles, or 2.42 percent

of the area of the county. Its tendency to drift has resulted in the formation of a typical dune topography.

The surface soil, to a depth of about 7 inches, is a sharp-grained brown sand. The subsurface to a depth of about 20 inches, is a brownish yellow sand. The subsoil is a sharp, coarse-grained yellow sand. Both the subsurface and subsoil contains some fine gravel.

Management.—Crop yields are low on this type. Wheat and rye are the principal crops grown. Quack grass is abundant. Farming should not be undertaken on it with extravagant expectations of making the soil highly productive by good farming methods and fertilizer treatment. Its productivity, however, can be increased by first applying limestone at the rate of about 2 tons per acre and growing sweet clover as a source of much-needed organic matter and nitrogen. If purchased fertilizers of any kind are used, they should be used experimentally until it is shown that the increase in returns justifies the expenditure. The use of much of this land for timber production is advisable. For results from experiments on sand, see the account of the Oquawka field, page 64.

Dune Sand (1581)

Dune Sand occurs, for the most part, in the northern part of the county in conjunction with River Sand (1580). Small sand dunes and "blowouts" have been formed where the wind has had an opportunity to drift the sand. Very little vegetation grows on this type. Some wire grass and wild vetch are found, and black jack oaks occur in places. The soil is a yellow sand from the surface to 40 inches or more and contains very little organic matter. This type is of little importance because of its small area and because it is of very little agricultural value. Experience has shown that this land may be made valuable by forestation, both as a source of timber and for pasture.

Gravelly Loam (1590)

Gravelly Loam consists of small areas in the northern part of the county and covers a total area of only 38 acres. It is used for pasture and is suited to nothing else.

(e) SWAMP AND BOTTOM-LAND SOILS

This group includes the bottom lands along the Mississippi and Rock rivers and their tributaries, and swamps and poorly drained lowlands. The soil is an alluvial formation and the land is largely subject to overflow. In former times, these swamps were lakes or part of the preglacial river channels. At the present time, the bottom lands along the Mississippi river in the western part of the county have been leveed, dredge ditches constructed, and pumping stations established, so that most of the area is cultivated. The total area of this group, consisting of thirteen soil types, occupies 7,963 square miles, or 18.57 percent of the area of the county.

Deep Brown Silt Loam (1426)

Deep Brown Silt Loam is the second largest area of overflow land in the county, comprizing an area of 17.51 square miles. Practically all the type is

located along the Mississippi river in the western part of the county and along Rock river.

The surface soil, which is about 8 inches in depth, is a heavy brown silt loam containing an appreciable amount of fine sand. The subsurface, in the upper 8 inches, varies from a light brown sandy loam to a gray or drab sandy silt loam; in the lower part it is a black silt loam. The subsoil, which begins at about 22 inches, varies from a brownish yellow silt loam to a drab silt loam.

Management.—This type is, for the most part, subject to moderate overflow. It needs no treatment other than good tillage.

Mixed Loam (1354, 1454)

Mixed Loam occupies 31.26 square miles, or about 7 percent of the county, and is found along the Mississippi and Rock rivers and also along the tributary streams. This type, as mapped, is made up of a number of distinct types which occur in areas that are too small to be successfully separated; moreover, since much of the type is subject to overflow, it is constantly being changed.

Management.—The overflow portions of this type require nothing more than good tillage. The portions which are no longer subject to overflow are becoming slightly acid and require the addition of light applications of limestone to grow sweet clover. Nitrogen should be supplied by growing clover crops at regular intervals and plowing down a portion of them. Probably no fertilizer treatment will prove profitable for many years.

Brown Sandy Loam (1460)

Brown Sandy Loam, Bottom, occupies an area of 5.17 square miles.

The surface soil, to about 8 inches in depth, is a heavy brown sandy loam, with a rather high percentage of fine sand. The subsurface extending to 18 inches is a yellowish brown sandy loam. The subsoil in the upper 12 or 14 inches consists of a plastic, grayish yellow, silty clay loam with enough sand to make it gritty, while in the lower part it is a gray to yellow sand with splotches of bright red iron concretions.

Management.—This type, as a rule, is not acid. It contains a higher percentage of clay in the three upper strata than is usually the case with this type and it is therefore easier to maintain the organic-matter and nitrogen supply than in a more open soil. The subsoil is not favorable to deep root penetration and for that reason, particular care must be exercised in maintaining a rich surface and subsurface soil. No experimental information is available regarding the fertilization of this soil. It is suggested that the various phosphates be tried and that in making the trials it be borne in mind that wheat usually responds to phosphate better than do other crops.

Yellow-Gray Fine Sandy Silt Loam (1344, 1444)

Yellow-Gray Fine Sandy Silt Loam, Bottom, covers an area of 6.42 square miles, or 1.49 percent of the area of the county.

The surface soil to a depth of 6 inches, varies from a light brown to a yellowish gray, fine sandy silt loam. The subsurface extending to 20 inches in

depth is a yellowish gray, fine sandy loam. The subsoil in the upper 10 inches is a yellowish gray sandy loam, while in the lower part it varies from a brown, fine sandy loam to a somewhat compact, yellow, clayey sand.

Management.—This type is well supplied with carbonates and is an excellent alfalfa and sweet clover soil. It is not well supplied with nitrogen or organic matter and particular attention should be given to increasing the amount of these constituents by growing clovers. The reader is referred to the discussion of the management of Yellow-Gray Silt Loam (534) for further suggestions regarding the management of this type (see page 16).

Black Sandy Loam (1461)

Black Sandy Loam occurs in a few low, poorly drained areas in the Rock river bottom.

The surface soil, extending to a depth of 8 inches, is a black sandy loam. The subsurface, extending from 8 to 16 inches, varies from a black to a yellowish brown or yellowish drab sandy loam. The subsoil varies from a drab to a yellow sand. Some of the areas have a gravel deposit of several feet in thickness at a depth of about 22 inches below the surface. This type, being poorly drained and also alkaline, is not productive. The area is small, and on the whole the type is of little importance.

River Sand (1480)

Only a few areas of River Sand, Bottom, were mapped in the county. It is similar to River Sand, Terrace (1580), excepting that it is not so well drained and is alkaline.

The surface soil is a brown sand to a depth of 3 or 4 inches, and the subsurface and subsoil are yellow sand.

Black Clay Loam (1420)

Black Clay Loam occurs almost entirely in the Rock river bottom. It covers an area of only 1.46 square miles. The areas of this soil type are usually lower in topography than those adjacent to them.

The surface soil, extending to a depth of 8 inches, is a plastic black clay loam. The subsurface, 8 to 16 inches, is a drabbish black clay loam. The subsoil in the upper 14 inches is a very plastic drab clay containing many snail shells, while below 30 inches, it is a drab clay loam and less plastic.

Management.—This type is alkaline and the alkali salts may be sufficiently concentrated to require the use of potash to overcome their harmful effects. Good underdrainage will gradually lessen the amount of alkali. Particular care should be used in maintaining a good supply of organic matter in order to help maintain a good physical condition and also to help in overcoming the effects of the alkali. No fertilizer treatment other than the use of potash, where necessary, is advised.

Drab Clay (1415)

Drab Clay is found almost exclusively in the Mississippi river bottom. It is flat in topography, but has been fairly well drained thru the construction of levees and dredge ditches. It covers an area of 1.24 square miles, or .29 percent of the area of the county.

The surface soil, to a depth of 7 inches, varies from a heavy, drabbish, silt loam to a plastic, drab, clay loam. The subsurface, 7 to 22 inches, varies from drab clay to mottled drab clay loam. The subsoil below 22 inches is drab clay.

Management.—This type is well supplied with the elements of plant food with the exception of nitrogen, but the soil is hard to work unless the moisture conditions are just right. The type is usually not alkaline, and since being leveed and drained, is gradually becoming acid. It is very necessary to maintain a good supply of fresh organic matter to help overcome the tendency towards poor physical condition and to furnish nitrogen for the growing crops.

Drab Clay Loam (1421)

Drab Clay Loam occurs in association with Drab Clay and often grades into that type. It has been formed where there has been very little current, so that the finest material has been carried in and deposited. The topography is flat. Drainage has been established thru the construction of dredges. Drab Clay Loam is found in the Mississippi river bottoms along the west side of the county. Thru an error, the type name has been omitted from the legend on three sections of the printed soil map.

The surface soil, which is about 6 inches deep, varies from a heavy brown clay loam to a plastic drab clay loam. The subsurface gradually changes from a drab clay loam to a plastic drab clay. The subsoil is a plastic, compact, drab clay.

Management.—The management requirements of this type are the same as for Drab Clay (1415).

Black Mixed Loam (1450)

Black Mixed Loam was formed in low, poorly drained, swampy areas. Within recent years, most of the areas have been drained so that crops can now be grown. Most of the areas are located along Rock river and its former channels. The type covers 11.86 square miles, or 2.77 percent of the area of the county.

The surface soil, to a depth of 7 inches, varies from a black silt loam to a black sandy loam or peaty loam. The subsurface, 7 to 20 inches, is usually a black clay loam with an appreciable amount of sand. The subsoil in the upper 12 inches is a drab clay loam containing considerable sand and gravel, and the lower part is a sticky drab clay.

Management.—This is a productive type of soil when well drained. Alkali is present on some areas in sufficient concentration to necessitate the use of a potash salt, while on others the plowing-down of a good growth of sweet clover in the spring for corn is a sufficient corrective for this condition. No fertilizer

treatment other than the above treatment for alkali, when necessary, is advised. Adequate provision should be made for maintaining the nitrogen and the supply of fresh organic matter by the frequent growth of legumes.

Black Mixed Loam On Rock (1450.5)

Black Mixed Loam On Rock occurs in the Rock river bottom. The underlying limestone rock comes to within less than 30 inches of the surface. The type occupies only .53 square mile.

The surface soil, to a depth of 7 or 8 inches, is a sandy black clay loam. The subsurface, 7 to 17 inches, varies from a black to drabbish, silty clay loam, with the limestone at about 17 inches as a rule. In a few places, where the limestone occurs about 22 to 24 inches below the surface, the subsoil is a plastic yellow clay.

This type is suitable only for pasture.

Deep Peat (1401)

Deep Peat occupies 2.61 square miles, or 1.21 percent of the area of the county. It occurs in areas which have been continuously wet, thus favoring the growth and accumulation of organic matter.

The surface soil, to a depth of about 7 inches, is well-decomposed black peat. The subsurface differs from the surface in that it contains more clay. The subsoil is rather variable in depth and in composition. It is usually peaty material down to about 30 inches and then a clayey muck. In places, the clayey muck occurs at a depth of 25 or 30 inches below the surface.

Management.—The first requirement in the management of this type is good drainage. The type is likely to be alkaline and usually the application of potash is necessary; however, the high percentage of clay near the surface suggests that the use of potash may not be necessary unless alkali is present in harmful amounts. Acid phosphate has been found to give good results on this type in neighboring states; however, it should be used in an experimental way until its value or lack of value has been proved.

Clayey Muck (1413)

Clayey Muck occurs in the northeastern part of the county in Meredosia slough. It covers only .03 square mile, or 19 acres.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order intelligently to interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The type is the unit of classification and each type has definite characteristics. In establishing types, the following factors are taken into account: the character of the horizons composing the soil as to depth and thickness, physical composition, structure, organic-matter content, color, reaction, and carbonate content; the topography; the native vegetation; and the geological origin of the soil.[1]

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

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[1] Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following explanations are inserted:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of four or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual*, soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated*, comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines*, including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation*, covering nearly the south third of the state
400 *Middle Illinoisan glaciation*, covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation*, covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation*, but now believed to be part of the upper Illinoisan
700 *Iowan glaciation*, lying in the central northern end of the state
800 *Deep loess areas*, including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines*, including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines*, including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation*, covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation*, lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands*, found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands*, those of the Wisconsin and Iowan glaciations
1500 *Terraces*, bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits*, formed by Lake Chicago, the enlarged glacial Lake Michigan

For further information regarding these geological areas the reader is referred to the general map published in Bulletins 123 and 193.

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken

by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 7.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron.* Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil conditions, which may result from poor drainage, poor physical condition, or from an actual deficiency in one or more of the elements of plant food.

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1] These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

Table 5 shows the requirements of some of our most common field crops with respect to the seven plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and seven from the soil. Nitrogen, one of these seven elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[3] (unleached)	...	10	100

[1] See footnote to Table 5.
[2] Young second year's growth ready to plow under as green manure.
[3] Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for

the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than

this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which has been ruined thru erosion.

Amounts to Apply.—If the soil is acid, limestone should be applied, the initial treatment being at the rate of 2 to 6 tons an acre, according to the degree of acidity. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonate of calcium and magnesium. The natural occurrence of these carbonates in the

soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

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[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4$_1$ have been found satisfactory. Some commercial firms are also offering similar preparations which are satisfactory.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be

the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, acid phosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either

in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per

acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth Year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to Those Occurring in Rock Island County)

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Two Farming Systems Provided

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system.

Definite Crop Rotations Followed

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Standard Soil Treatments Used

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grain to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

EXPERIMENTS ON BROWN SILT LOAM

Several experiment fields have been conducted on Brown Silt Loam at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

So far as known, the oldest soil experiment field in the United States is located on Brown Silt Loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow,

who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves, and the halves are subdivided into quarters. On one plot, corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904. Besides farm manure, phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. In 1925 the phosphates were evened up to a total of 3,300 pounds of bone meal and 13,200 pounds of rock phosphate and their application discontinued. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre. From 1903 until 1920, legumes were seeded in the corn on the south half of each plot. Legumes, chiefly red clover until 1918 and sweet clover since that time, have been seeded in the oats on the south half of Plot 4.

Table 7 gives the yearly records of the crop yields from the Morrow plots, and Table 8 presents the results in summarized form.

Summarizing the data from these Morrow plots into two periods, with the second period beginning in 1904, when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the untreated, continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and

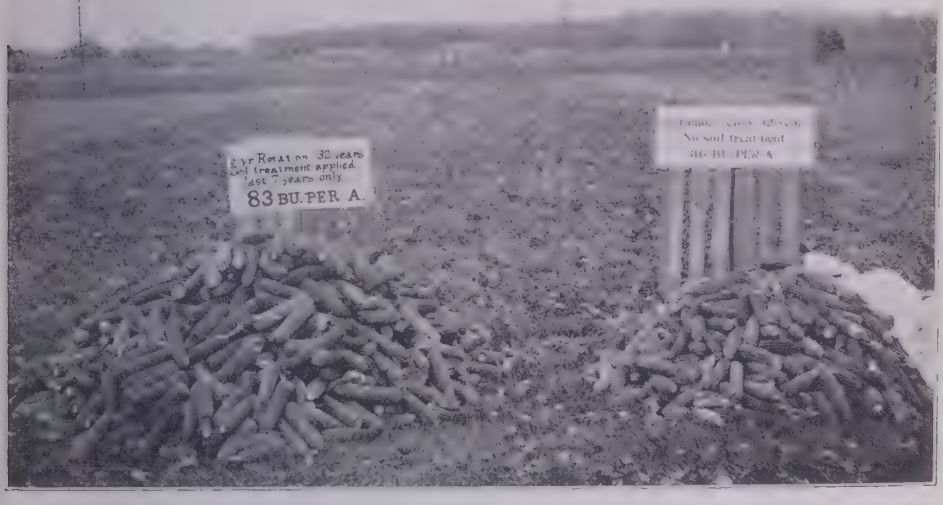


FIG. 2.—CORN ON THE MORROW PLOTS

TABLE 7.—URBANA FIELD, MORROW PLOTS

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Year	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None	....	....	....	....	....	....
1888	None	54.3	49.5	....	....	48.6	....
1889	None	43.2	....	37.4	....	....	(4.04)
1890	None	48.7	54.3	....	....	....	(1.51)
1891	None	28.6	33.2	....	....	....	(1.46)
1892	None	33.1	....	37.2	70.2	....	....
1893	None	21.7	29.6	....	34.1	....	....
1894	None	34.8	....	57.2	....	65.1	....
1895	None	42.2	41.6	....	....	22.2	....
1896	None	62.3	....	34.5	....	....	....
1897	None	40.1	47.0	....	....	....	....
1898	None	18.1	....	....	....	....	....
1899	None	50.1	44.4	....	53.5	....	....
1900	None	48.0	....	41.5	....	....	....
1901	None	23.7	33.7	....	34.3	....	....
1902	None	60.2	....	56.3	....	54.6	....
1903	None	26.0	35.9	....	....	....	(1.11)
1904	None	21.5	....	17.5	55.3	....	....
1904	MLP	17.1	....	25.3	72.7	....	....
1905	None	24.8	50.0	....	....	42.3	....
1905	MLP	31.4	44.9	....	....	50.6	....
1906	None	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP	35.8	....	52.4	....	....	(1.74)[1]
1907	None	29.0	47.8	....	80.5	....	....
1907	MLP	48.7	87.6	....	93.6	....	....
1908	None	13.4	....	32.9	....	40.0	....
1908	MLP	28.0	....	45.0	....	44.4	....
1909	None	26.6	33.0	....	....	....	(.65)[2]
1909	MLP	31.6	64.8	....	....	....	(1.73)[2]
1910	None	35.9	....	33.8	58.6	....	....
1910	MLP	54.6	....	59.4	83.3	....	....
1911	None	21.9	28.6	....	....	20.6	....
1911	MLP	31.5	46.3	....	....	38.0	....
1912	None	43.2	....	55.0	....	....	16.3[1]
1912	MLP	64.2	....	81.0	....	....	20.5[1]
1913	None	19.4	29.2	....	33.8	....	....
1913	MLP	32.0	25.0	....	47.8	....	....
1914	None	31.6	....	33.6	....	39.6	....
1914	MLP	39.4	....	58.2	....	60.4	....
1915	None	40.0	49.0	....	....	....	24.2[1]
1915	MLP	66.0	81.2	....	....	....	27.1[1]
1916	None	11.2	....	37.5	27.8	....	....
1916	MLP	10.8	....	64.7	40.6	....	....
1917	None	40.0	48.4	....	....	68.4	....
1917	MLP	67.0	81.4	....	....	86.9	....
1918	None	13.6	....	27.2	....	....	(2.58)
1918	MLP	32.6	....	59.3	....	....	(4.04)
1919	None	24.0	30.8	....	52.2	....	....
1919	MLP	43.4	66.2	....	70.8	....	....
1920	None	28.2	....	37.2	....	52.2	....
1920	MLP	54.4	....	51.6	....	69.7	....
1921	None	19.8	30.6	....	....	....	(.26)[4]
1921	MLP	42.2	68.4	....	....	....	(1.33)[5]
1922	None	24.6	....	39.3	49.2	....	....
1922	MLP	39.4	....	55.8	65.3	....	....
1923	None	15.0	17.2	....	....	53.4	....
1923	MLP	31.4	46.4	....	....	66.6	....
1924	None	28.0	....	36.0	....	....	(1.83)
1924	MLP	38.0	....	68.5	....	....	(4.42)

[1] Soybeans. [2] In addition to the hay, .64 bushel of seed was harvested. [3] In addition to the hay, 1.17 bushels of seed were harvested. [4] In addition to the hay, .53 bushel of seed was harvested. [5] In addition to the hay, .85 bushel of seed was harvested.

TABLE 8.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY

Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None.....	39 7	41.0	44.0	48.0	47.6	(2 03)
		21 crops	*10 crops*	*11 crops*	*7 crops*	*7 crops*	*7 crops*[1]
1904 to 1924	None.....	25.7	36.5	35.0	51.1	45.2	(1.71)
	MLP.....	39.9	61.2	56.5	67.7	59.5	(2.86)

[1]Including all legume crops evaluated as clover hay.

clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here provision is made for each crop in the rotation to be represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1919, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rotation rate of 6 tons per acre in the three-year rotation and 4 tons per acre in the two-year rotation in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further

application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the yearly rate of one-half ton per acre.

Phosphorus (**P**) was applied on Plots 6 to 9 at the yearly rate of 25 pounds per acre in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per year was substituted for the bone meal on one-half of each of these plots. These applications continued until 1918, when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre yearly. In 1925 the phosphates were evened up to a total amount applied of 3,300 pounds of bone meal and 13,200 pounds of rock phosphate per acre, after which the applications are to be discontinued. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K**) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. In addition, legumes were seeded in the same manner as on Plots 2, 4, 6, and 8. The purpose of this extra heavy treatment is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate amounts of the elements of plant food.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. The *grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of crop residues along with legumes, is exemplified in Plots 2, 4, 6, and 8; and the *livestock system,* in which farm manure is utilized for soil enrichment, is represented in the corresponding Plots 3, 5, 7, and 9.

Table 9 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus, the crop residues and the manure appear about equally effective; but where phosphorus is not applied, manure has been decidedly more effective than residues, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact during the fourteen years there were five clover failures, when soybeans were substituted. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

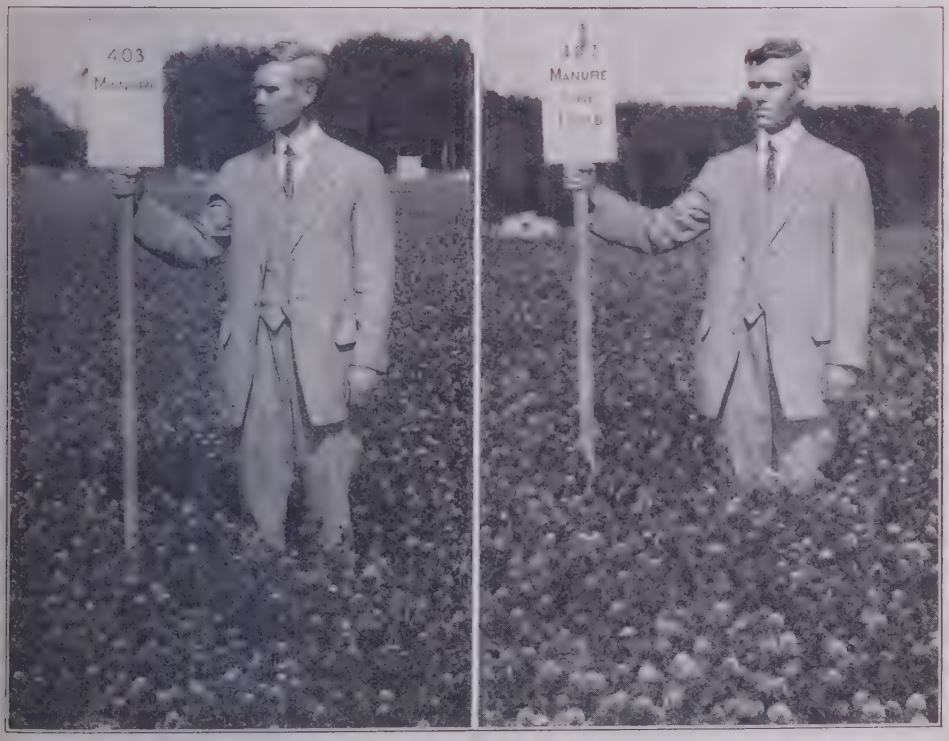
TABLE 9.—URBANA FIELD, DAVENPORT PLOTS

Average Annual Yields 1911-1924—Bushels or (tons) per acre

Plot	Soil treatment applied	Corn *14 crops*	Oats *15 crops*[1]	Wheat *14 crops*	Clover *9 crops*		Soybeans *5 crops*	Alfalfa *12 crops*
1	0	53.1	53.2	26.6	(1.96)	.....	(1.47)	(2.64)
2	R	53.8	54.5	29.3	(.40)	1.23	19.8	(2.76)
3	M	64.3	62.6	29.9	(2.25)	.....	(1.62)	(2.71)
4	RL	62.9	57.8	32.4	(.58)	1.40	20.3	(2.99)
5	ML	69.0	64.8	34.8	(2.78)	.....	(1.67)	(3.24)
6	RLP	69.8	71.3	42.2	(.72)	1.53	23.5	(4.10)
7	MLP	71.2	70.7	41.1	(3.39)	.....	(1.97)	(4.19)
8	RLPK	70.9	73.1	40.0	(.73)	1.20	25.5	(4.30)
9	MLPK	69.0	72.3	40.0	(3.39)	.....	(2.20)	(4.22)
10	Mx5LPx5	65.1	72.0	40.1	(3.11)	.....	(2.22)	(4.26)

[1]Including a nurse crop of oats, grown with alfalfa seeding in 1924.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus



Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 3.—CLOVER ON THE DAVENPORT PLOTS

are applied in addition to the crop residues, an increase of 16.7 bushels of wheat, over the yield of the untreated land, has been obtained as a fourteen-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are similar to Plots 6 and 7, respectively, except that potassium has been applied to the former. The small gains appearing in certain cases are counterbalanced by losses in others, and on the whole, potassium treatment has not been profitable on these plots.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and livestock.

The summarized results presented in Table 10 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 4.—WHEAT ON THE UNIVERSITY SOUTH FARM

TABLE 10.—URBANA FIELD, SOUTH FARM

Average Annual Yields 1908–1919—Bushels or (tons) per acre

Soil treatment applied[6]	Corn[3] 9 crops	Oats[3] 9 crops	Wheat[4] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]					
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(2.31)	(1.28)
MLP	64.1	59.6	43.9	(2.82)	(1.58)

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]					
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans					
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1] Results from Series 300 and 800 are omitted on account of variation in soil type.
[2] Soybeans when clover fails.
[3] Only seven crops with limestone.
[4] Only one crop with limestone.
[5] Average of five crops.
[6] All phosphorus plots received ½ ton per acre of limestone in 1903.

conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

On the whole, the residues have not returned as high yields as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is relatively little difference between the effect of manure and of residues.

Limestone, which has been used in the southwest rotation, appears to have produced no increase of consequence to any of the crops except oats. The comparison may be somewhat impaired, however, by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are of especial interest because this element has been applied on this field solely in the form of raw rock

TABLE 11.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM

Twelve-Year Average (1908–1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus	63.2	56.6	52.3	53.2	45.3	41.6

[1] Clover 3 crops, and soybeans 7 crops.
[2] Clover 5 crops, and soybeans 5 crops.
[3] Soybeans 9 crops.

phosphate. The figures in almost every case show an increase in yield where the phosphate has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records from this field furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 11 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

The Aledo Field

An experiment field on Brown Silt Loam is located in Mercer county just west of Aledo. This field has been in operation since 1910. From its physical aspects this field should be well adapted to experimental work, the land being unusually uniform in topography and in soil profile.

There are two general systems of plots and they are designated as the major and the minor systems. The major system comprizes four series (numbered 100, 200, 300, 400) made up of 10 plots each. The plots were handled substantially as described for standard treatment until 1922, when a number of changes were introduced. The rotation practiced was wheat, corn, oats, and clover, until 1923, when the cropping program also was modified.

Table 12 presents a summary of the results showing the average annual yields obtained for the period beginning when complete soil treatment came into sway and ending with the year 1922, after which the crop rotation was changed.

Soybeans have been substituted several times for red clover when the latter failed. For the present purpose only the grain crops are considered in the summary. The lower section of Table 12 gives comparisons in terms of crop increases intended to indicate the effect of the different fertilizing materials applied.

In looking over these results we may observe first the beneficial effect of animal manure on all crops, but especially marked on the corn. This suggests

TABLE 12.—ALEDO FIELD: GENERAL SUMMARY OF THE GRAIN CROPS

Average Annual Yields 1912-1922—Bushels per acre

Serial Plot No.	Soil treatment applied	Wheat *8 crops*	Corn *11 crops*	Oats *10 crops*
1	0	29.9	57.3	59.0
2	M	34.0	68.7	63.8
3	ML	33.4	70.8	65.0
4	MLP	35.5	72.2	64.7
5	0	31.2	59.4	61.2
6	R	31.5	63.2	60.4
7	RL	32.4	69.5	64.5
8	RLP	36.9	70.4	65.2
9	RLPK	35.0	70.8	67.2
10	0	31.1	58.7	56.0
	M over 0	3.3	10.2	5.1
	R over 0	.8	4.7	1.7
	ML over M	−.6	2.1	1.2
	RL over R	.9	6.3	4.1
	MLP over ML	2.1	1.4	−.3
	RLP over RL	4.5	.9	.7
	RLPK over RLP	−1.9	.4	2.0

the advisability of carefully conserving and regularly applying all stable manure. Residues, alone, have as yet shown little effect.

Where limestone has been applied, there is usually a small increase in average yields, the increase becoming particularly marked in the corn crop in the residues system.

Aside from the case of the wheat, the results show little or no effect from adding rock phosphate to the treatment, and at prevailing prices the cost of applying the phosphate would not be covered. However, the economic story has not all been told, for the application of lime and phosphate on these plots is to be discontinued in order to observe the residual effects. The results of the next few years, therefore, will be awaited with great interest.

For the effect of potassium treatment, we may compare Plots 8 and 9. No significant response appears as the result of applying potassium, so far as these common field crops show.

A number of problems have arisen out of the experience on this and other experiment fields which call for some revision of the investigations described above, and accordingly certain changes are to be made in the future conduct of these plots which are intended especially to throw more light upon the problems of liming and applying phosphorus. (See Soil Report No. 29, Mercer County Soils).

Experiments on the Minor Series

The so-called minor system of plots (Series 500, 600, 700, 800) on the Aledo field is given over to a comparison of the effectiveness of different carriers of phosphorus.

In this experiment each series contains four plots. Plot 1 receives residues treatment only; Plot 2 receives residues and phosphorus in one of the forms

under test; Plot 3 receives residues, limestone, and phosphorus; and Plot 4 is similar to Plot 3 with phosphorus omitted. On one series, steamed bone meal (bP) is used as the carrier of phosphorus and is applied at the rate of 200 pounds per acre per year. On another series, acid phosphate (aP) is applied at the yearly rate of 333⅓ pounds per acre. On a third series, rock phosphate (rP) serves as the source of phosphorus, applied at the rate of 666⅔ pounds per acre yearly, and on the last series, basic slag phosphate (sP) is applied at the rate of 250 pounds per acre yearly.

The yields for all crops harvested on these plots during the first nine years are recorded in Table 13. Table 14, which is derived from Table 13, shows differences in crop yields presumed to have resulted from applying the various forms of phosphatic fertilizers for the nine crops harvested since the beginning of the applications up to 1924. In computing these comparisons all residues plots are combined into a single average for the respective crops, as are all lime-residues plots, and these figures stand as checks against the corresponding phosphated plots.

Aside from the soybeans, the figures show without exception more or less crop increase on the phosphorus plots, no matter what the form of carrier employed. The difficulty, however, of arriving at a general conclusion regarding the comparative economy in the use of these different phosphorus materials is obvious, for all depends upon their relative cost, which fluctuates from time to time. Furthermore, the prices received from farm produce likewise fluctuate; and to complicate matters still further, these fluctuations do not necessarily run parallel with those of the fertilizer cost. However, one may readily compute for himself the relative economy of producing these crop increases by applying any set of prices for crops and fertilizers which appear to be most applicable according to prevailing market conditions.

TABLE 13.—ALEDO FIELD: PHOSPHATE EXPERIMENT
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied[1]	1916[2] Corn	1917[2] Oats	1918[2] Soy-beans	1919 Wheat	1920 Corn	1921 Oats	1922 Clover hay	1923 Corn	1924 Corn
501	R	53.4	85.5	18.9	32.4	72.8	48.9	(2.88)	83.5	58.2
502	RbP	61.7	91.7	19.0	34.7	86.4	61.9	(3.25)	82.7	66.0
503	RLbP	61.5	90.6	23.2	35.6	87.3	53.3	(3.48)	82.5	66.8
504	RL	55.1	80.5	22.6	32.9	77.7	47.7	(2.61)	88.2	60.3
601	R	55.2	84.7	19.5	33.0	71.2	53.6	(3.17)	84.7	57.3
602	RaP	57.8	87.7	18.7	38.3	87.1	60.9	(3.23)	82.5	65.9
603	RLaP	64.7	83.4	23.1	38.2	88.1	52.3	(3.53)	77.6	64.7
604	RL	51.9	81.7	24.6	32.8	84.9	50.2	(3.06)	84.1	51.9
701	R	54.3	83.1	20.8	34.2	75.6	52.8	(3.41)	82.8	61.2
702	RrP	58.8	83.3	23.3	36.7	80.4	63.0	(3.60)	87.8	69.3
703	RLrP	57.2	81.2	28.1	36.7	80.2	53.3	(3.82)	86.6	70.8
704	RL	52.1	81.7	26.9	34.1	82.0	48.9	(3.15)	84.6	62.5
801	R	57.6	73.8	18.0	33.7	68.1	54.8	(2.62)	74.3	58.8
802	RsP	56.4	87.8	20.6	38.1	81.0	66.2	(3.66)	80.0	69.1
803	RLsP	53.3	78.9	23.7	38.4	83.6	57.0	(3.63)	82.0	70.2
804	RL	51.8	77.5	21.8	33.3	70.4	59.8	(2.99)	82.6	59.9

[1]Bone meal (bP) at the rate of 200 pounds per acre per year.
Acid phosphate (aP) at the rate of 333⅓ pounds per acre per year.
Rock Phosphate (rP) at the rate of 666⅔ pounds per acre per year.
Slag phosphate (sP) at the rate of 250 pounds per acre per year.
All minerals applied once in the rotation ahead of the wheat crop.
[2]No residues.

TABLE 14. -ALEDO FIELD: CROP INCREASES FOR VARIOUS FORMS OF PHOSPHATE BASED UPON RESULTS IN TABLE 13
1916-1924

Comparison of treatments	Wheat *1 crop*	Corn *4 crops*	Oats *2 crops*	Clover *1 crop*	Soybeans *1 crop*
Bone meal and residues over residues	1.4	7.4	9.7	(.23)	−.3
Bone meal, lime, and residues over lime and residues	2.3	5.8	5.9	(.53)	−.8
Acid phosphate and residues over residues	5.0	6.5	7.2	(.21)	−.6
Acid phosphate, lime and residues over lime and residues	4.9	5.0	1.8	(.58)	−.9
Rock phosphate and residues over residues	3.4	7.3	6.0	(.58)	4.0
Rock phosphate, lime and residues over lime and residues	3.4	4.9	1.2	(.87)	4.1
Slag phosphate and residues over residues	4.8	4.8	9.9	(.64)	1.3
Slag phosphate, lime, and residues over lime and residues	5.1	3.5	1.4	(.68)	−.3

For the purpose of furnishing an illustration of such a computation, the following set of arbitrary prices may be assumed as representing approximately average market conditions for the past ten years: wheat, $1.25 per bushel; corn, 75 cents; oats, 45 cents; soybeans, $1.50; and clover, $15 per ton. For the cost of the various phosphatic materials the following estimates are used: bone meal, $40 per ton; acid phosphate, $24; rock phosphate, $12; and slag phosphate, $20. These values seem to be conservative enough. The figures for crop values are all under the average December 1 farm price quotations for the ten-year period 1914-1923. Furthermore, it may be pointed out that the quantities of phosphatic materials employed in these experiments are, with the possible exception of the slag phosphate, greater than ordinarily would be used, or need to be used, in good farm practice.

Figured on the basis of these prices, it appears that both bone meal and acid phosphate, as used on these plots, have been applied at a financial loss, whether accompanied by limestone or not, while rock phosphate and slag phosphate have each yielded a profit. Counting in all crops, the net loss for bone meal was 4 cents per acre per year when applied without limestone, and 41 cents applied with limestone. The use of acid phosphate without limestone resulted in a loss of 17 cents, while with limestone the loss was 66 cents. Rock phosphate produced a profit of $1.14 when used without limestone, but with limestone the profit was reduced to 36 cents. Slag phosphate furnished the most profitable return of any of the phosphorus carriers, producing an average profit of $2.04 an acre yearly when used without limestone and 60 cents used with limestone.

In considering these figures let it be emphasized again that the order of these values might easily be shifted by a relatively small change in commodity prices.

Considering the results from the standpoint of limestone as applied on the plots of the minor series, the following observations are to be made.

Limestone at the rate of 4 tons per acre was applied to Plots 3 and 4 in 1912, when the land was still under alfalfa, and another dressing was added in 1917,

TABLE 15.—ALEDO FIELD: CROP INCREASES FOR LIMESTONE BASED UPON RESULTS IN TABLE 13
1916-1924

Comparison of treatments	Wheat *1 crop*	Corn *4 crops*	Oats *2 crops*	Clover *1 crop*	Soybeans *1 crop*
Residues, limestone over residues	.0	2.0	−1.2	(−.07)	4.7
Residues, limestone, bone meal over residues, bone meal	.9	.3	−4.8	(.23)	4.2
Residues, limestone, acid phosphate over residues, acid phosphate	−.1	.5	−6.4	(.30)	4.4
Residues, limestone, rock phosphate over residues, rock phosphate	.0	−.4	−5.9	(.22)	4.8
Residues, limestone, slag phosphate over residues, slag phosphate	.3	.7	−9.0	(.33)	3.1

after the present experiments were under way. The effect of this limestone, in terms of crop increase, is set forth in Table 15.

Comparing, first, the results from the check plots, which receive no phosphorus, it appears that the limestone used with residues alone has been of benefit to the corn and the soybean crops only.

Considering all treatments as a whole, the soybeans exhibit a consistent gain in yield from the use of limestone, while oats, on the other hand, respond by a consistent loss. Wheat and corn on the whole show a rather indifferent response. If we consider the money value of these crop increases on the same basis as above, we find a gross return for limestone, applied without phosphate, of $1.30 per acre per year. Limestone with bone meal has returned, in gross, 83 cents per acre per year; with acid phosphate, 73 cents; with rock phosphate, 44 cents; and with slag phosphate, 65 cents. It is doubtful, therefore, whether limestone, used with phosphates in the manner described has, up to the present time, paid its cost on these plots. The Aledo field represents one of these borderline cases, so to speak, in which the upper soil is neutral or only slightly acid and the lime requirement, therefore, not yet very marked. As time goes on, however, and cropping continues, the need of lime will develop. It is planned to discontinue liming on these plots until its need becomes manifest, and in so doing the annual cost of the limestone already applied will become automatically reduced, so that net returns which hitherto have represented a loss may sooner or later result in a positive profit.

The Galesburg Field

Another field which should be of interest in this Report, because of its proximity to Rock Island county, is the Galesburg field. This field lay six miles west of Galesburg. It was established in 1904 and was continued until 1918. It was laid out into three series of twenty plots each with treatments as indicated in Table 16. The original rotation was corn, corn, oats, wheat, clover, and timothy, but this was changed in 1909 to corn, corn, oats, clover, wheat, and clover.

All phosphorus was applied in the form of rock phosphate at the rate of 500 pounds per acre per year. At the beginning, a dressing of 1,300 pounds of

TABLE 16.—GALESBURG FIELD: GENERAL SUMMARY OF CROP YIELDS

Average Annual Yields 1908-1918—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn following clover *6 crops*	Corn following corn *5 crops*	Corn average *11 crops*	Oats *5 crops*	Wheat *4 crops*	Barley *1 crop*	Clover *4 crops*	Soybeans *4 crops*
1	L.....	54.8	45.9	50.8	44.4	21.7	22.5	(2.12)	(1.16)
2	RL.....	65.6	53.1	59.9	47.5	26.6	27.1	.....	13.8
3	ML.....	73.8	61.1	68.0	47.8	28.9	25.5	(2.67)	(1.56)
4	CvML.....	75.1	60.8	68.6	47.4	28.4	25.6	(2.45)	(1.53)
5	L.....	61.6	51.0	56.7	46.8	25.2	21.7	(2.37)	(1.27)
6	LP.....	70.6	58.1	64.9	51.1	33.8	24.2	(2.86)	14.1
7	RLP.....	74.9	58.0	67.2	51.8	36.4	29.8	.....	15.6
8	MLP.....	76.1	65.1	71.1	51.0	32.7	26.8	(2.90)	(1.65)
9	CvMLP ...	74.7	66.1	70.8	50.8	33.3	33.0	(2.91)	(1.62)
10	L.....	59.7	47.3	54.1	45.9	22.2	23.0	(1.94)[1]	12.7
11	LPK.....	68.8	60.9	65.2	49.4	32.7	22.7	(3.03)	15.5
12	RLPK.....	75.1	61.7	69.0	48.2	34.8	38.4	.....	15.9
13	MLPK....	73.8	63.8	69.3	49.8	32.3	29.7	(3.11)	(1.75)
14	CvMLPK..	74.8	67.0	71.3	48.0	33.3	35.1	(3.27)	(1.67)
15	L.....	60.7	46.1	54.0	43.4	19.6	25.5	(2.08)	(1.31)
16	R.....	62.8	49.7	56.8	43.7	24.7	33.3	.....	12.5
17	RP.....	71.1	54.2	63.4	51.9	36.0	31.5	.....	14.2
18	RPK.....	74.3	56.4	66.2	51.9	39.2	32.6	.....	14.3
19	RLNPK...	79.1	60.4	70.6	52.4	36.5	39.1	.....	17.4
20	0.....	59.3	47.6	54.0	43.3	25.8	24.9	(1.82)	(1.14)

[1]Only 2 crops from this plot.

limestone per acre was applied and no more was added until 1913, when an application of 4 tons per acre was made. The potassium was applied in 100 pounds of potassium sulfate per acre. On Plot 19 nitrogen was applied in 200 pounds of dried blood per acre yearly. Some legume cover crops were grown in the corn.

A general summary of the annual crop yields is assembled in Table 16. Following are some of the salient points brought out by a study of the various possible comparisons.

1. Residues without limestone produced very little effect on crop yields, but used with limestone there was a noticeable increase in the residues plots over the non-residues plots.

2. Manure used in the liberal manner of these experiments, along with limestone, produced very beneficial effects. Measured by crop increases, the effect of manure and limestone was about twice that of residues and limestone. It should be borne in mind, however, in this connection that in this system the land received regularly manure at the rate of 3 tons per acre per year, a practice that would be difficult to carry out on many farms.

3. The use of limestone alone, all crops considered, resulted in a financial loss. In combination with residues, however, limestone produced a beneficial effect.

4. Rock phosphate in the residues system produced very pronounced and profitable increases in crop yields, used either with or without limestone. Also, without residues the increases in crop yields were large.

Used with animal manure, however, the increases resulting from phosphate were not nearly so large; in fact, the increases attributable to phosphorus in the manure system are scarcely sufficient to cover the cost of the rock phosphate employed. This is a commonly observed result, explained probably by the fact that the manure itself carries a considerable quantity of phosphorus which supplies directly much of the crops' need for this element of plant food.

5. Potassium in the form of potassium sulfate appears in five different fertilizer combinations on these plots, but the various possible comparisons show no significant effect from potassium. In a large proportion of the cases the figures indicating increase carry the minus sign, and altogether the small differences exhibited are doubtless well within experimental error.

6. Nitrogen, as applied in the form of dried blood and in combination with residues, limestone, phosphorus, and potassium, likewise proved ineffective, resulting in a considerable economic loss thru cost of material.

7. Cover crops, in the three different combinations tried, produced no significant effect so far as crop yields indicate.

The Kewanee Field

Another field in the vicinity of Rock Island county is the Kewanee field, located in Henry county about three miles southwest of Kewanee. This field has been under way since 1915. The crops grown are wheat, corn, oats, and clover. The arrangement of plots and the treatments applied are indicated in Table 17. This table includes the yields of the grain crops, omitting for the present purpose the clover yields.

Summarizing the data in the fashion of Table 17 the following observations may be made.

TABLE 17.—KEWANEE FIELD: GENERAL SUMMARY OF THE GRAIN CROPS
Average Annual Yields 1917-1924—Bushels per acre

Serial Plot No.	Soil treatment applied	Wheat *6 crops*	Corn *8 crops*	Oats *8 crops*
1	0	31.0	54.1	58.8
2	M	32.7	63.5	68.1
3	ML	35.6	67.6	71.3
4	MLP	38.8	67.6	70.1
5	0	32.2	55.1	60.9
6	R	32.9	56.9	58.7
7	RL	33.1	65.7	63.0
8	RLP	38.1	68.8	65.9
9	RLPK	38.2	71.7	67.5
10	0	30.6	50.6	55.3
	M over 0	1.4	10.2	9.8
	R " 0	1.6	3.6	.4
	ML " M	2.9	4.1	3.2
	RL " R	.2	8.8	4.3
	MLP " ML	3.2	0.0	−1.2
	RLP " RL	5.1	3.1	2.9
	RLPK " RLP	.1	2.9	1.6

1. The response to treatment with stable manure stands out clearly in the increase in production.

2. Residues without limestone have not produced a very decided effect on crop yields.

3. The effect of limestone appears to have been beneficial used either with manure or with residues.

4. Phosphorus, as usual, has been more effective applied with residues than with manure. In the residues system the rock phosphate has been applied with profit, while in the manure system the increases in crop yield are not sufficient to cover the cost.

5. Potassium has produced no effect upon the yields of these crops that can be considered significant.

EXPERIMENTS ON BLACK CLAY LOAM

The Hartsburg Field

The results of experiments on the Hartsburg field are introduced as representing the soil type Black Clay Loam. This field is located in Logan county just east of Hartsburg. The work began in 1913. The field was laid off into five series of 10 plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series. The soil treatments are as indicated in Table 18. The table summarizes, by crops, the yields of grain for the period during which the plots have been under full treatment.

The outstanding feature of these results is the large increase in yields produced by residues, which even exceeds the increase brought about by the use of stable manure.

TABLE 18.—HARTSBURG FIELD: GENERAL SUMMARY OF THE GRAIN CROPS

Average Annual Yields 1913-1924—Bushels per acre

Serial Plot No.	Soil treatment applied	Wheat *9 crops*	Corn *12 crops*	Oats *11 crops*
1	0	23.9	44.0	46.6
2	M	29.3	52.6	51.8
3	ML	36.1	59.5	57.8
4	MLP	39.0	58.5	57.7
5	0	31.8	48.3	44.7
6	R	34.3	59.3	54.6
7	RL	32.8	64.0	52.5
8	RLP	36.5	61.9	56.8
9	RLPK	35.4	61.7	56.2
10	0	32.3	49.0	47.9
	M over 0	0.0	5.5	4.4
	R " 0	5.0	12.2	7.2
	ML " M	6.8	6.9	6.0
	RL " R	−1.5	−2.1	4.7
	MLP " ML	2.9	−1.0	− .1
	RLP " RL	3.7	−2.1	4.3
	RLPK " RLP	− .9	− .2	− .6

The behavior of limestone on this field is rather peculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure, limestone gave a substantial increase in all grain crops, while with residues, the effect on both wheat and corn appears negative.

Altho rock phosphate has given some increases in wheat yield in both manure and residues systems, the results with other crops have been such as to render the use of this material unprofitable on this field.

The addition of potassium appears to have produced a slightly depressing effect upon the yields of all grain crops.

It may be mentioned that new experiments have been recently started on these plots which are designed to answer some of the questions brought out by the foregoing results. For example, the effect of applying phosphorus in other carriers and in different combinations, as well as testing the residual effect of phosphate already applied, will be tried.

EXPERIMENTS ON YELLOW SILT LOAM

Inasmuch as about one-fifth of the area of Rock Island county is made up of Yellow Silt Loam, much of which is subject to erosion, it is believed that an account of some experiments on the Vienna field will be of interest here.

The Vienna Field

In 1906 the University acquired a sixteen-acre tract of badly eroded land characteristic of the region, near Vienna in Johnson county. The whole area with the exception of about three acres had been abandoned because so much of the surface soil had washed away and there were so many gullies as to render further cultivation of this land unprofitable. Experiments were started at once to reclaim this land, the different methods described below being used for this purpose.

The field was divided into five sections. The sections designated as A, B, and C were divided into four plots each, and D into three plots. On section A, which included the steepest part of the area and contained many gullies, the land was built up into terraces at vertical intervals of five feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without doing much washing.

On section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges sufficiently high so that on the occasion of a heavy rainfall if the water breaks over it will run over in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about eight loads of manure per acre were turned under each year for the corn crop.

The land on section D was washed to about the same extent as that of section C. As a check on the different methods of reducing erosion, the land on

FIG. 5.—VIEW OF AN UNIMPROVED HILLSIDE JUST OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 6

section D was farmed in the most convenient way, without any special effort being made to prevent washing.

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

Sections A, B, C, and D were not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons per acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except D which had but three plots.

FIG. 6.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD. THIS LAND FORMERLY HAD BEEN BADLY ERODED. COMPARE WITH FIG. 5

TABLE 19.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields, 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(0.68)
B	Embankments and hillside ditches	32.4	12.7	(0.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(0.80)
D	Check	14.1	4.6	(0.21)

Table 19 contains a summarized statement of the results obtained.

These results indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels per acre, as against 14.1 bushels for series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 5 and 6 will serve to indicate the possibility of improving this type of soil.

EXPERIMENTS ON DUNE SAND

The Oquawka Field

In 1913 the University established an experiment field on Dune Sand, Terrace, in Henderson county, near the Mississippi river. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

Table 20 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 46.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite indifferent to treatment with rock phosphate. The analyses show, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

Altho the results show an increase of 3.5 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment. The slight increases appearing in the other crops are scarcely significant.

A significant fact which the above summary does not bring out is that improvement under favorable treatment has been progressive as evidenced by a very marked upward trend in production after the first few years. For example,

TABLE 20.—OQUAWKA FIELD: SUMMARY SHOWING AVERAGE ANNUAL YIELDS 1915-1924
Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *10 crops*	Soybeans *8 crops*		Wheat *10 crops*	Sweet clover[1] *8 crops*		Rye *8 crops*	Alfalfa *7 crops*
			Hay *5 crops*	Seed *4 crops*		Hay *4 crops*	Seed *4 crops*		
1	0.....	17.1	(.89)	8.9	8.4	(.00)	.00	12.2	(.34)
2	M.....	21.6	(1.01)	11.1	11.6	(.00)	.00	13.9	(.55)
3	ML.....	28.1	(1.27)	14.8	15.2	(1.20)	.80	26.4	(2.07)
4	MLP.....	27.0	(1.20)	14.9	15.5	(1.26)	.74	25.1	(2.15)
				Seed *9 crops*		Hay *2 crops*	Seed *6 crops*		
5	0.....	16.8	.....	5.9	10.5	(.00)	.00	12.7	(.06)
6	R.....	19.6	.....	6.4	11.7	(.00)	.00	13.7	(.05)
7	RL.....	33.8	.....	10.3	14.4	(1.47)	1.26	26.5	(1.81)
8	RLP.....	32.7	.....	10.2	14.7	(1.39)	1.21	26.4	(1.77)
9	RLPK.....	36.0	.....	9.6	13.5	(1.53)	1.43	28.5	(1.89)
10	0.....	15.8	(.60)	6.6[2]	9.0	(.00)	.00	10.9	(.05)

[1]In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots and the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 11.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre on Plot 10. [2]4 crops.

it may be noted that the yields under the limestone-residues treatment for the entire 10-year period are: corn, 33.8 bushels; soybeans, 10.3 bushels; wheat, 14.4 bushels; and rye, 26.5 bushels per acre, but if we take the average of these

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 7.—ALFALFA ON OQUAWKA FIELD IN 1918

same plots for the last five years the yields are: corn, 42.4 bushels; soybeans, 12.8 bushels; wheat, 19.6 bushels; and rye, 29.7 bushels per acre.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

EXPERIMENTS ON DEEP PEAT

The Manito Field

The results secured on the Manito experiment field which was located on Deep Peat and which was in operation during the years 1902 to 1905, inclusive, are presented in Table 21.

There were ten plots receiving the treatments indicated in the table. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. However, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the total yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) appear to be insufficient.

TABLE 21.—MANITO FIELD: DEEP PEAT

Annual Corn Yields—Bushels per acre

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905
1	None	10.9	8.1	None	17.0	12.0
2	None	10.4	10.4	Limestone, 4000 lbs	12.0	10.1
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs Kainit, 1200 lbs	49.6	47.3
4	Kainit, 600 lbs Acidulated bone, 350 lbs	30.3	33.3	Kainit, 1200 lbs Steamed bone, 395 lbs	53.5	47.6
5	Potassium chlorid, 200 lbs	31.2	33.9	Potassium chlorid, 400 lbs	48.5	52.7
6	Sodium chlorid, 700 lbs	11.1	13.1	None	24.0	22.1
7	Sodium chlorid, 700 lbs	13.3	14.5	Kainit, 1200 lbs	44.5	47.3
8	Kainit, 600 lbs	36.8	37.7	Kainit, 600 lbs	44.0	46.0
9	Kainit, 300 lbs	26.4	25.1	Kainit, 300 lbs	41.5	32.9
10	None	[1]	14.9	None	26.0	13.6

[1] No yield was taken in 1902 because of a misunderstanding.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 32

RANDOLPH COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, and L. H. SMITH

URBANA, ILLINOIS, DECEMBER, 1925

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Randolph county was conducted, and Mr. H. C. Wheeler, who, as leader of the field party, was in direct charge of the mapping.

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RANDOLPH COUNTY SOILS

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RANDOLPH COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER and L. H. SMITH[1]

LOCATION AND CLIMATE OF RANDOLPH COUNTY

Randolph county is located on the Mississippi river about thirty miles south of East St. Louis and covers an area of 593 square miles. The topography varies from flat to undulating over much of the northern and eastern portions, to rough and hilly in a belt two to ten miles wide adjacent to the Mississippi river. Twenty-five percent of the area of the county is mapped as being subject to serious erosion because of its rough topography.

The climate of Randolph county is characterized by a wide range between the temperature extremes of winter and summer. The lowest temperature recorded at Sparta for the years 1910 to 1923 was 18° below zero in 1918, while the highest was 108°, also in 1918. During this period of fourteen years, there were nine winters in which the temperature reached zero or below, and nine summers which registered a temperature of 100° or above. The average date of the last killing frost in spring is April 10; the earliest in fall, October 24. The average length of the growing season is, therefore, 198 days. The shortest growing season recorded was 172 days in 1918; the longest was 232 days in 1922.

The average annual precipitation at Sparta from 1910 to 1923 was 42.03 inches, while at Chester, which is located on the Mississippi river, the average annual precipitation for the period 1911 to 1923 was 44.88 inches, a difference of 2.85 inches. The distribution of rainfall thruout the year is good, as shown by the following monthly averages computed from the Sparta records: January, 3.67 inches; February, 1.93; March, 3.09; April, 4,61; May, 4.58; June, 3.47; July, 2.65; August, 5.37; September, 3.23; October, 4.47; November, 2.20; December, 3.00.

AGRICULTURAL PRODUCTION

Randolph county is primarily agricultural, altho coal mining is an important industry in the county. According to the Fourteenth Census of the United States, there were 2,324 farms in Randolph county in 1919. This number represents a decrease of 211 farms during the preceding ten years. The average size of farm was 139 acres, 106.5 of which were improved. Forty percent of the farms were operated by tenants in 1920, 34 percent in 1909, and 29 percent in 1899.

The following figures show the acreage and production for 1919 of the principal crops grown in the county:

---

[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	31,031	438,165 bu.	14.1 bu.
Oats	13,653	254,317 bu.	18.6 bu.
Wheat	95,263	1,274,026 bu.	13.3 bu.
Timothy	6,582	7,857 tons	1.19 tons
Timonthy and clover mixed	2,063	2,612 tons	1.26 tons
Clover	13,190	16,120 tons	1.22 tons
Alfalfa	1,724	4,249 tons	2.46 tons
Silage crops	2,174	7,968 tons	3.66 tons
Corn for forage	7,469	6,280 tons	.84 tons

The total value of all crops produced in the county for 1919 was estimated at $5,409,708.

It should be borne in mind that the above figures represent the yields of only a single season. A report from the U. S. Department of Agriculture places the yields for four important crops as an average for the ten year period 1911-1920 as follows: corn, 21.3 bushels an acre; oats, 26.6 bushels; hay, 1.11 tons; wheat, 13.2 bushels. Evidently the year 1919, which furnished the Census data, was unfavorable for corn and oats.

The livestock interests are of considerable importance, as shown by the following figures, which are also for the year 1919:

Animals and Animal Products	*Number*	*Value*
Horses	9,196	$ 728,543
Mules	2,881	345,373
Beef cattle	2,698	132,385
Dairy cattle	15,522	721,424
Sheep	2,924	30,276
Swine	19,376	221,207
Chickens and other poultry	235,743	201,750
Chickens and eggs sold	.....	1,002,757
Dairy products sold	.....	452,694

The total value of livestock and livestock products was $3,836,000. It should be noted that over $1,000,000 was received in 1919 from the sale of chickens and eggs.

Fruit growing is of some importance in Randolph county, and it might be further extended to good advantage. The Census reports that 14,000 quarts of small fruits, 45,000 bushels of apples, and 57,000 pounds of grapes were produced in 1919.

SOIL FORMATION

GEOLOGICAL HISTORY

Much of the material which forms the soils of Randolph county was deposited during the Glacial period. During this period conditions were such that ice accumulated in great masses in the region of Labrador, west of Hudson Bay, and in the Rocky Mountains. The ice masses pushed outward from their centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. There were at least six of these great advances, each one followed by a long interval of time.

In advancing from the distant northern centers of accumulation, the ice gathered up and transported all sorts and sizes of rock material. The character of this transported material varied with the character of the rocks over which the ice sheet advanced. During the advance a large amount of fine material,

known as rock flour, was produced by the grinding action of the moving ice. This fine material was transported southward by the glacial streams and later blown over the land by the wind. It now constitutes the major part of the mineral portion of the soil.

Only one of the great glacial advances, the Illinoisan, covered the area which now constitutes Randolph county, but later glaciers which did not advance so far south were of perhaps equal importance in that they contributed a large amount of rock flour, which, when distributed over the land, is known as loess. This material occurs as a blanket covering the glacial drift over practically the entire upland area of Randolph county.

The thickness of the drift varies from about 5 feet in the vicinity of Red Bud to 80 feet or more in other portions of the county. The loess blanket also varies in thickness. In the northwest corner of the county it is so shallow as to affect the productivity of the soil unfavorably, while in a belt adjacent to the Mississippi river it extends far below the depth to which the roots of crop plants penetrate.

The Mississippi river has been an important factor in the development of the soils in the bottom land adjacent to it, and it is still an important factor in determining their management. A considerable portion of this bottom is subject to annual overflow and other portions are in danger of flooding during periods of very high water.

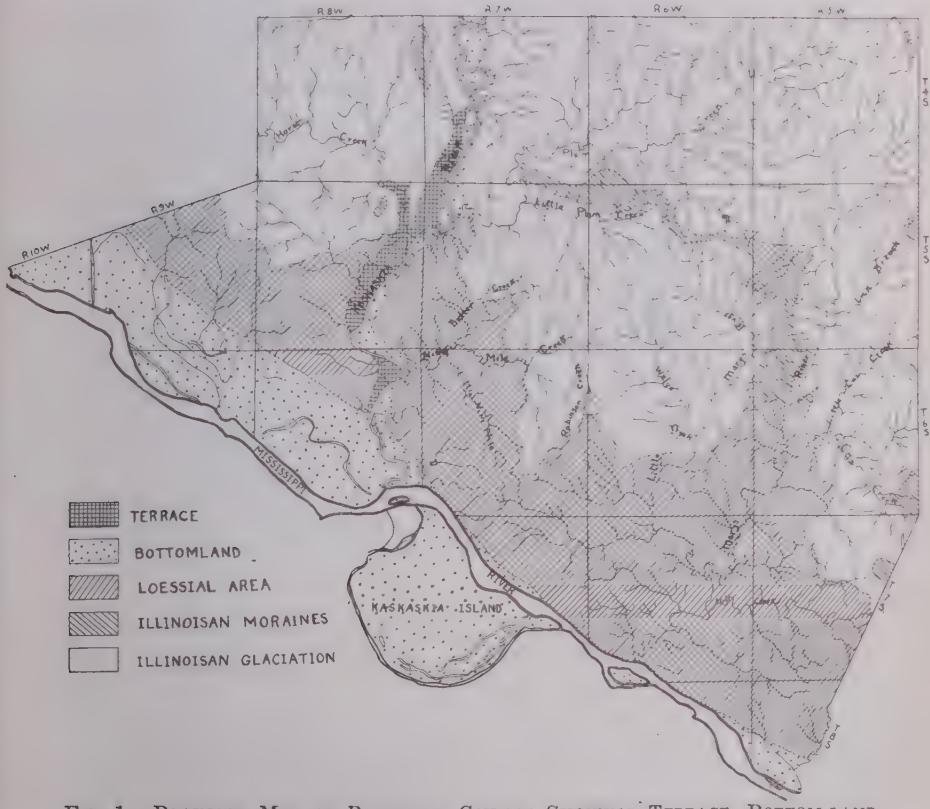


FIG. 1.—DRAINAGE MAP OF RANDOLPH COUNTY SHOWING TERRACE, BOTTOM-LAND, LOESSIAL, AND MORAINAL AREAS

PHYSIOGRAPHY AND DRAINAGE

The topography of Randolph county is very diversified. The central and northern portions of the county are flat to undulating, with narrow eroded slopes adjacent to the streams. A broken, hilly belt varying in width from two to ten miles extends in a northwest-southeast direction adjoining the Mississippi bottom. The southeastern portion of this belt is particularly hilly and broken.

The drainage of the county is almost entirely thru Mary's creek and Kaskaskia river and their tributaries, directly into the Mississippi river. The divide between these two drainage systems runs thru Coulterville, Sparta, Palestine, and thence to Fort Gage. The reader is referred to the accompanying drainage map, which shows the drainage systems of the county.

The following altitudes of a few places will give some idea of the general elevation of Randolph county: Coulterville, 542 feet; Baldwin, 465; Red Bud, 450; Evansville, 423; Sparta, 545; Chester, 384; Menard, 385; Prairie du Rocher, 397.

SOIL GROUPS

The soils of Randolph county are classified under the following groups:

(a) *Upland Prairie Soils,* including the upland soils that have not been covered with forests, at least not for any great length of time.

(b) *Upland Timber Soils,* including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) *Terrace Soils,* including second bottom lands, formed by deposits from overloaded streams; and gravel or sand outwash plains formed by broad sheets of water arising from the melting of the glaciers.

(d, e) *Swamp and Bottom-Land Soils,* including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

(f) *Residual Soils,* including rock outcrop areas, and soils formed in place thru weathering of rocks.

Table 1 gives a list of the soil types found in Randolph county, classified according to the groups described above. It also shows the area of each type in square miles and in acres, and its percentage of the total area of the county. The accompanying map, shown in three sections, gives the location and boundary of each soil type found in the county.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the Appendix to this report.

LEGEND

(a) UPLAND PRAIRIE SOILS

- 30 330 Gray silt loam on tight clay
- 28 328 Brown-gray silt loam on tight clay

(b) UPLAND TIMBER SOILS

Shallow Loess

- 34 334 Yellow-gray silt loam
- 35 335 Yellow silt loam
- 32 332 Light gray silt loam on tight clay
- 364 Yellow-gray sandy loam
- 365 Yellow sandy loam

Deep Loess Areas

- 834 Yellow-gray silt loam
- 835 Yellow silt loam
- 84 Yellow-gray fine sandy silt loam
- 848 Yellow fine sandy silt loam

Ridge Soils

- 234 Yellow-gray silt loam
- 235 Yellow silt loam

(c) 1500 TERRACE SOILS

- Yellow-gray fine sandy silt loam
- 1560 Yellow-gray sandy loam
- 1560.5 Light brown sandy loam
- 1562 Yellow-gray sandy loam on clay
- 534 Yellow-gray silt loam on clay
- 1532 Light gray silt loam on tight clay
- 1536 Gray clay
- 1538 Drab clay

(d) 1300 OLD SWAMP AND BOTTOM-LAND SOILS

- 1331 Deep gray silt loam
- 1324 Brown silt loam
- 1354 Mixed loam
- 319 Yellow-brown fine sandy loam
- 363 Mixed sandy loam
- 1315 Drab clay

000 Residual

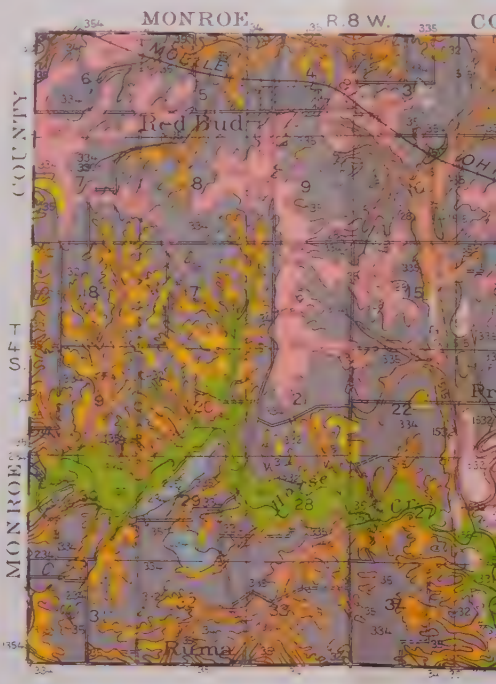
200 Ridge Soils

300 Lower Illinoisan Glaciation

800 Deep Loess Areas

(e) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

- 14261 Brown silt loam on clay
- 14281 Brown silt loam on tight clay
- 14262 Brown silt loam on sand
- 1454 Mixed loam
- 1460 Brown sandy loam
- Brown fine sandy loam
- 15 1415 Drab clay
- 1422 Brown-gray clay loam on tight clay



SOIL SURVEY MAP OF R

UNIVERSITY OF ILLINOIS AGRICULTU

(f) 000 RESIDUAL

- Stony loam
- Rock outcrop, limestone
- Rock outcrop, sandstone
- Small areas stony loam
- Small areas rock outcrop, limestone
- Small areas rock outcrop, sandstone

OLPH COUNTY
EXPERIMENT STATION

Scale
0 1/8 1/2 1 2 Miles

A. HOEN & CO. LITH. BALTIMORE

TABLE 1.—SOIL TYPES OF RANDOLPH COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (300)			
330	Gray Silt Loam On Tight Clay	28.33	18 131	4.78
328	Brown-Gray Silt Loam On Tight Clay	12.78	8 179	2.15
		41.11	26 310	6.93
	(b) Upland Timber Soils (200, 300, 800)			
	Shallow Loess			
334	Yellow-Gray Silt Loam	168.02	107 533	28.33
335	Yellow Silt Loam	50.90	32 576	8.41
332	Light Gray Silt Loam On Tight Clay	3.54	2 266	.60
364	Yellow-Gray Sandy Loam	1.10	704	.19
365	Yellow Sandy Loam	.64	410	.11
	Deep Loess			
834	Yellow-Gray Silt Loam	42.68	27 315	7.18
835	Yellow Silt Loam	61.01	39 046	10.29
844	Yellow-Gray Fine Sandy Silt Loam	16.60	10 624	2.80
845	Yellow Fine Sandy Silt Loam	28.59	18 298	4.82
	Ridge Soils			
234	Yellow-Gray Silt Loam	9.08	5 811	1.54
235	Yellow Silt Loam	6.04	3 866	1.02
		388.20	238 449	65.29
	(c) Terrace Soils (1500)			
1544	Yellow-Gray Fine Sandy Silt Loam	.75	480	.13
1564	Yellow-Gray Sandy Loam	1.95	1 248	.33
1560.6	Light Brown Sandy Loam	.46	294	.08
1564.1	Yellow-Gray Sandy Loam On Clay	.86	550	.14
1534.1	Yellow-Gray Silt Loam On Clay	2.07	1 325	.35
1532	Light Gray Silt Loam On Tight Clay	4.14	2 650	.70
1516	Gray Clay	1.15	736	.19
1515	Drab Clay	.75	480	.13
		12.13	7 763	2.05
	(d, e) Swamp and Bottom-Land Soils (1300, 1400)			
1331	Deep Gray Silt Loam	24.44	15 642	4.29
1326	Brown Silt Loam	3.25	2 080	.55
1354, 1454	Mixed Loam	50.67	32 428	8.55
1379	Yellow-Brown Fine Sandy Loam	5.19	3 322	.87
1363	Mixed Sandy Loam	.44	281	.07
1315, 1415	Drab Clay	19.93	12 755	3.36
1426.1	Brown Silt Loam On Clay	10.12	6 477	1.70
1428.1	Brown Silt Loam On Tight Clay	1.33	851	.22
1426.2	Brown Silt Loam On Sand	5.92	3 789	1.00
1460	Brown Sandy Loam	8.56	5 478	1.44
1471	Brown Fine Sandy Loam	1.94	1 242	.33
1422.1	Brown-Gray Clay Loam On Tight Clay	1.55	992	.26
		133.34	85 337	22.64
	(f) Residual Soils (000)			
098	Stony Loam	.42	269	.07
099	Rock Outcrop, Limestone	.82	525	.14
099	Rock Outcrop, Sandstone	1.08	691	.18
		2.32	1 485	.39
	Water	16.01	10 246	2.70
	Total	593.11	379 590	100.00

INVOICE OF THE ELEMENTS OF PLANT FOOD IN RANDOLPH COUNTY SOILS

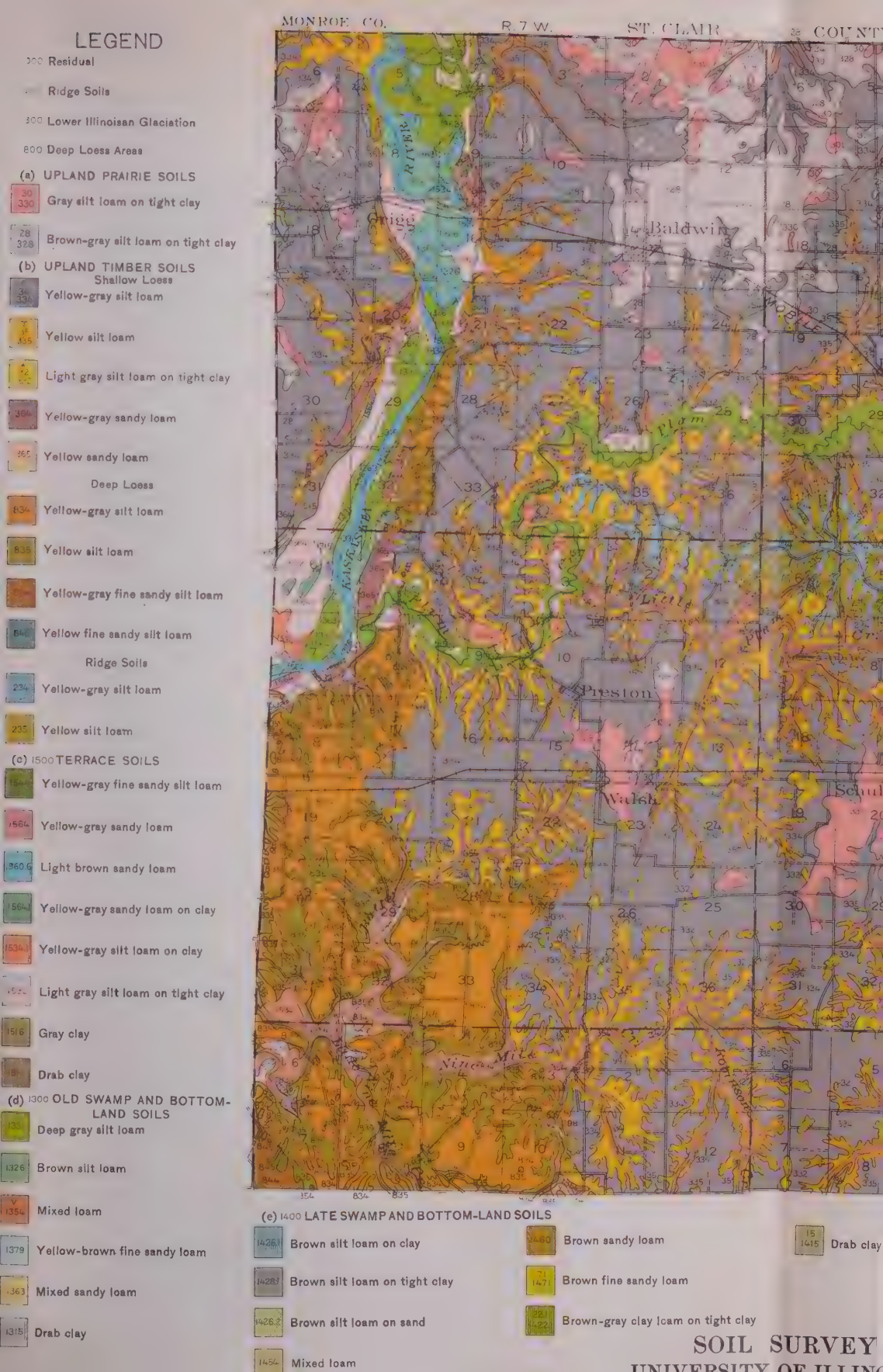
In order to obtain a knowledge of its chemical composition, each soil type is sampled and subjected to chemical analysis for its important plant-food elements. For this purpose samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). In the common kinds of soil the upper sampling stratum corresponds approximately to 2 million pounds of dry soil per acre, the middle sampling stratum to approximately twice this quantity, and the lower stratum to three times as much.

This, of course, is a purely arbitrary division of the soil section, which is very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil; but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to as *surface, subsurface,* and *subsoil* in the descriptions of the soil types. By this system of sampling we have represented separately three zones for plant feeding. The upper, or surface layer, includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, and other fertilizing materials are incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food elements actually present in the soil strata sampled and analyzed. It should be understood, however, that the rate at which these elements are liberated from their insoluble forms—a matter of at least equal importance—is governed by many factors and is not necessarily proportional to the total amounts of the elements present in the soil.

For convenience in making application of the chemical analyses, the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. The assumption is made that for ordinary types of soil the three different strata weigh 2 million, 4 million, and 6 million pounds per acre, as already explained. While these values are only an approximation, it is believed that they will suffice for the purpose intended. It is a simple matter to convert these figures back to the percentage basis in case one desires to consider the information in that form.

Because of the extreme variations frequently found within a given soil type, no attempt is made to include in the tabulated results figures purporting to represent the amount of limestone or the degree of acidity. In examining each soil type in the field, however, numerous qualitative tests are made which furnish general information regarding the soil reaction; and in the discussion of the soil types which follow, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping and soil treatment. Therefore, in considering a particular field it often is desirable to determine its lime requirement, and in this connection the reader



LEGEND

300 Residual

Ridge Soils

300 Lower Illinoisan Glaciation

800 Deep Loess Areas

(a) UPLAND PRAIRIE SOILS

330 Gray silt loam on tight clay

328 Brown-gray silt loam on tight clay

(b) UPLAND TIMBER SOILS

Shallow Loess

Yellow-gray silt loam

Yellow silt loam

Light gray silt loam on tight clay

Yellow-gray sandy loam

Yellow sandy loam

Deep Loess

834 Yellow-gray silt loam

835 Yellow silt loam

Yellow-gray fine sandy silt loam

Yellow fine sandy silt loam

Ridge Soils

234 Yellow-gray silt loam

235 Yellow silt loam

(c) 1500 TERRACE SOILS

Yellow-gray fine sandy silt loam

1564 Yellow-gray sandy loam

1560 Light brown sandy loam

1564 Yellow-gray sandy loam on clay

1534 Yellow-gray silt loam on clay

Light gray silt loam on tight clay

1516 Gray clay

Drab clay

(d) 1300 OLD SWAMP AND BOTTOM-LAND SOILS

Deep gray silt loam

1326 Brown silt loam

1354 Mixed loam

1379 Yellow-brown fine sandy loam

1363 Mixed sandy loam

1315 Drab clay

(e) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

1428 Brown silt loam on clay

1428 Brown silt loam on tight clay

1426.2 Brown silt loam on sand

1454 Mixed loam

1460 Brown sandy loam

1471 Brown fine sandy loam

1422 Brown-gray clay loam on tight clay

1415 Drab clay

SOIL SURVEY

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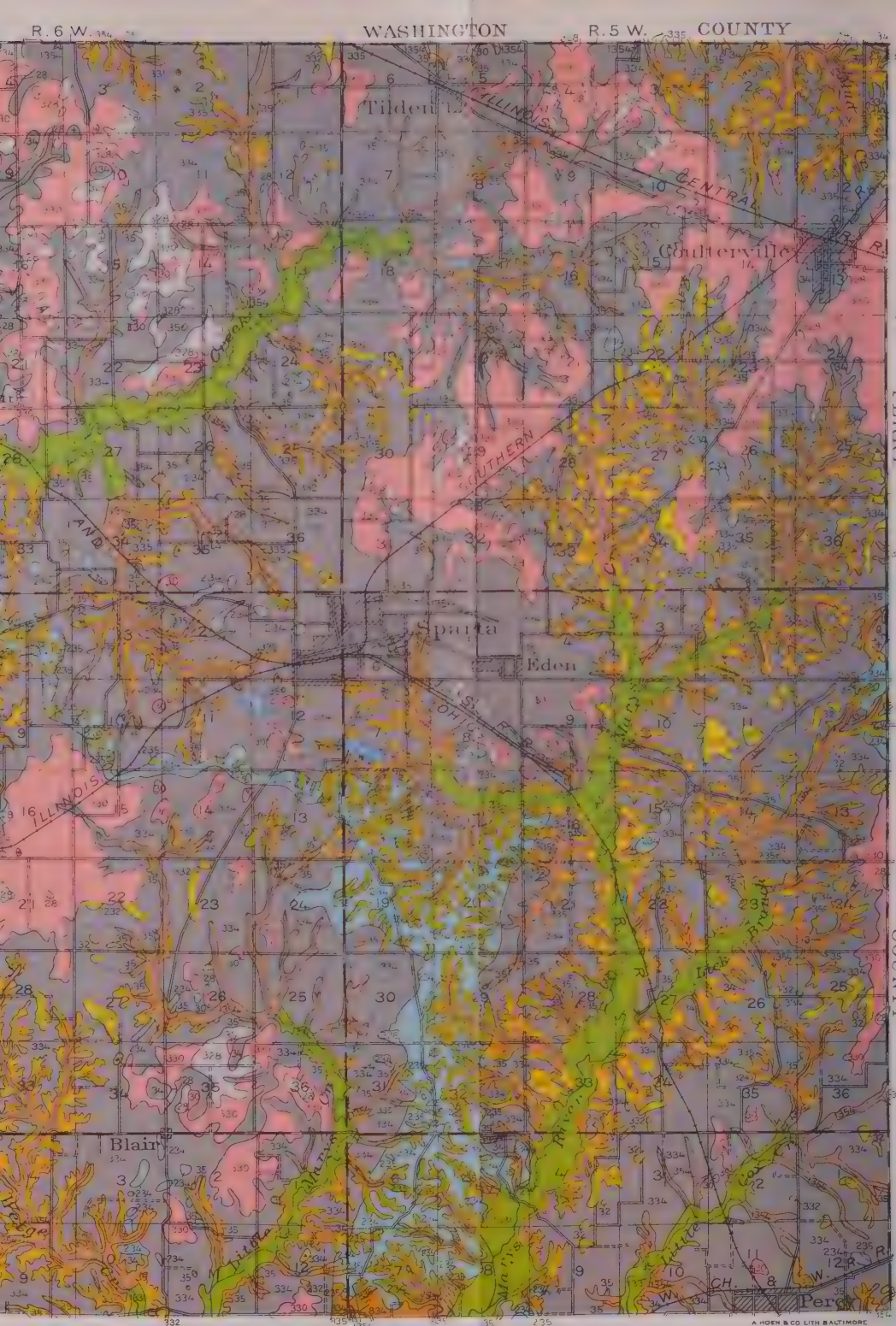

(f) 000 RESIDUAL

- 98 / 098 Stony loam
- 99 / 099 Rock outcrop, limestone
- 99 / 099 Rock outcrop, sandstone
- Small areas stony loam
- Small areas rock outcrop, limestone
- Small areas rock outcrop, sandstone

AP OF RANDOLPH COUNTY
AGRICULTURAL EXPERIMENT STATION

Scale
0 ¼ ½ 1 2 Miles

is referred to the section in the Appendix dealing with the application of limestone (page 34).

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amounts of organic carbon (which serves as a measure of the total organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil of each type in Randolph county.

In connection with this table attention is called to the variation among the soil types with respect to their content of the different plant-food elements. It will be seen from the analyses that the variation in the organic-carbon content of the different soils is accompanied by a parallel variation in the nitrogen content; the organic-carbon content is usually from 10 to 12 times that of the total nitrogen. This close relationship is explained by the well-established facts that all organic matter of the soil contains nitrogen, and also that most of the soil nitrogen (usually 98 percent or more) is present in a state of organic combination. This close relationship is also maintained in the middle and lower sampling strata.

The organic matter and the accompanying nitrogen show considerable variation among the different soil types, tho they are comparatively low thruout the county. Of the thirty-one types of soil for which analyses are reported in this county, only five types contain more than 40,000 pounds of organic carbon in the surface stratum of an acre. These are Drab Clay (Terrace), Stony Loam (Residual), and three types in the swamp and bottom-land area, namely, Brown Silt Loam On Clay, Drab Clay, and Brown-Gray Clay Loam On Tight Clay. These types together occupy but 32.77 square miles or only 5.52 percent of the area of the county. The soils in the remainder of the county range in organic-carbon content from a minimum of 13,700 pounds an acre in Light Brown Sandy Loam, up to 38,240 pounds in the Brown Silt Loam, Bottom. The total nitrogen values are correspondingly low, being in these two types, 1,360 and 3,460 pounds, respectively. Because of the widespread deficiency of both nitrogen and organic matter in these soils, it is particularly important to grow legume crops frequently as green manures and plow them down, in addition to conserving and using all the animal manure which can be produced.

Other elements are not so closely associated with each other as are organic matter and nitrogen, tho there is some degree of correlation between sulfur, another element used by growing plants, and organic carbon. This is because a considerable tho varying proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of the organic matter. The sulfur content of Randolph county soils is fairly low; it ranges in the surface soil from 420 pounds to 1,000 pounds an acre. This is partly accounted for by the low organic-matter content. Another factor is the atmospheric supply; sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous oxid of sulfur is soluble in water and consequently is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption, the amount of sulfur thus added to the soil is relatively large. At Urbana, during the eight-year period from 1917 to 1924, there was added

to the soil by the rainfall 3.5 pounds of sulfur an acre a month as an average. Similar observations have been made in localities in southwestern Illinois for shorter periods. At Sparta, Randolph county, in 1921, there was added in the rainfall 3.51 pounds of sulfur an acre in May, 7.78 pounds in August, and 9.96 pounds in September. At Ewing, Franklin county, during the entire season of 1921 the average monthly precipitation contained 2.27 pounds of sulfur an acre. These figures will afford some idea of the amount of sulfur added by rain and also of the wide variation in these amounts under different conditions. On the whole these facts would indicate that the sulfur added from the atmosphere sufficiently supplements that contained in the soil so that a need for sulfur fertilizers is not at all likely in Randolph county.

The potassium content of the soil ranges from 21,660 pounds an acre in Light Gray Silt Loam On Tight Clay to 40,220 pounds in Brown Silt Loam On Sand. From a quantitative point of view the least of these amounts is far above maximum crop requirements. However, the rate at which potassium is liberated in available condition from these large reserves varies widely, and the recommendations concerning potassium fertilizers in another part of this report are an indication that crop yields are limited on some soils by a deficiency of available potassium.

The phosphorus content of the upland and terrace soils of the county is low, while the bottom-land soils average nearly twice as much of this element. The smallest amount is found in Light Gray Silt Loam On Tight Clay, where it is but 440 pounds an acre. The largest amount, 2,300 pounds an acre, is in Brown Silt Loam On Clay, Bottom.

The amounts of soil calcium are, on the whole, rather low but no lower than is to be expected in soils which are acid. Soil acidity and calcium deficiencies are very frequently, but not always, associated. The smallest amount of calcium, 4,460 pounds an acre, is contained in Light Gray Silt Loam On Tight Clay. The largest amount in non-carbonate soils is 18,600 pounds in Brown Silt Loam On Clay, Bottom. Two soils containing calcium carbonate in the surface stratum—Brown Sandy Loam, Bottom, and Residual Stony Loam—contain 21,770 pounds and 51,180 pounds of calcium an acre respectively. Calcium is utilized by crops in fairly large amounts, so that in soils low in calcium content this element may not become available rapidly enough to supply crop needs. The liming of such soils, however, supplies any calcium deficiencies in addition to correcting acidity.

The soil content of magnesium in Randolph county averages about two-thirds as high as that of calcium, altho there are a few exceptional cases where it exceeds the calcium. The smallest amount found is 2,860 pounds an acre.

Considering the crop requirements for magnesium, it is doubtful whether magnesium ever becomes a limiting factor in crop production. This statement, however, does not imply a superiority of high calcium limestone over dolomitic or magnesian limestone. The usual commercial grades of high calcium and magnesian limestones are approximately equal in neutralizing value, and both types of stone also contain an abundance of calcium to make good any soil deficiencies in this element.

LEGEND

000 Residual

200 Ridge Soils

300 Lower Illinoisan Glaciation

800 Deep Loess Areas

(a) UPLAND PRAIRIE SOILS

30 330 Gray silt loam on tight clay

28 328 Brown-gray silt loam on tight clay

(b) UPLAND TIMBER SOILS

Shallow Loess

Yellow-gray silt loam

35 335 Yellow silt loam

32 332 Light gray silt loam on tight clay

Yellow-gray sandy loam

365 Yellow sandy loam

Deep Loess

834 Yellow-gray silt loam

Yellow silt loam

Yellow-gray fine sandy silt loam

Yellow fine sandy silt loam

Ridge Soils

234 Yellow-gray silt loam

235 Yellow silt loam

(c) 1500 TERRACE SOILS

Yellow-gray fine sandy silt loam

1584 Yellow-gray sandy loam

1560.6 Light brown sandy loam

1564 Yellow-gray sandy loam on clay

1534.1 Yellow-gray silt loam on clay

1532 Light gray silt loam on tight clay

1516 Gray clay

Drab clay

(d) 1300 OLD SWAMP AND BOTTOM-LAND SO

1330 Deep gray silt loam

1326 Brown silt loam

Y 1354 Mixed loam

1379 Yellow-brown fine sandy loam

1363 Mixed sandy loam

1315 Drab clay

(e) 1400 LATE SWAMP AND BOTTOM-LAND SO

1426 Brown silt loam on clay

1428.1 Brown silt loam on tight clay

1426.2 Brown silt loam on sand

SOIL SURVEY MAP OF

UNIVERSITY OF ILLINOIS AGRICU

ANDOLPH COUNTY

RAL EXPERIMENT STATION

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper stratum or with each other, it is necessary to bear in mind that the data as given for the middle and lower sampling strata are on the basis of 4 million and 6 million pounds of soil, and should therefore be divided by two and three, respectively, before comparing them with each other or with the data for the upper stratum, which is on a basis of 2 million pounds.

With this in mind it will be noted, in comparing the three strata with each other, that all the soil types diminish rather rapidly in organic matter and nitrogen with increasing depth, and that this diminution is very marked even in the middle stratum. Ordinarily the percentages of the other elements except sulfur remain about the same or increase slightly in the lower strata; sulfur in nearly all cases decreases with increasing depth. There is a tendency for phosphorus to be low in the middle stratum; this is probably due to the removal of phosphorus by the roots of growing plants and its later incorporation with the surface soil in the accumulated plant residues.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is impossible to obtain this information exactly, especially for the deeper-rooted crops, it seems probable that practically all the feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together, for a given soil type, the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

Considered in this manner the tables reveal a rather wide variation in the abundance of the various elements in the different soil types, when measured by crop requirements. We may compare in this way two extreme soil types in the county—Drab Clay, Bottom, and Yellow-Gray Silt Loam, Upland. These are among the most extensive soil types in the county. They contain in the first 40 inches 15,370 and 5,610 pounds of nitrogen an acre, which is equivalent to the amount present in the same number of bushels of corn since a bushel of corn contains approximately a pound of nitrogen. Drab Clay thus contains nearly three times as much of this element as Yellow-Gray Silt Loam. Drab Clay also contains considerably more phosphorus and potassium than Yellow-Gray Silt Loam—8,720 pounds of phosphorus (equivalent to 51,400 bushels of corn), as compared with 5,070 pounds (equivalent to 29,900 bushels of corn). The total amounts of potassium in the two soil types are 237,900 and 180,610 pounds respectively (approximately equivalent to 1,252,000 and 950,000 bushels of corn).

These two soil types vary widely in calcium content, Drab Clay containing 95,080 pounds in the first 40 inches and Yellow-Gray Silt Loam, only 35,350 pounds. The amount of calcium in the soil is not of so great importance directly in connection with the corn crop as it is with respect to legumes. A ton of red clover hay, for example, contains approximately 29 pounds of calcium, and these two soils therefore contain respectively as much calcium as would be removed in 3,270 and 1,120 tons of red clover hay.

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF RANDOLPH COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES
Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (300)							
330	Gray Silt Loam On Tight Clay	23 010	2 130	570	730	24 020	4 090	5 490
328	Brown-Gray Silt Loam On Tight Clay	32 980	2 680	720	540	26 340	4 480	79 200
	(b) Upland Timber Soils (200, 300, 800)							
	Shallow Loess							
334	Yellow-Gray Silt Loam	23 880	1 760	670	580	27 270	4 600	5 610
335	Yellow Silt Loam	23 820	1 760	760	420	32 460	8 860	9 080
332	Light Gray Silt Loam On Tight Clay	16 040	940	440	420	26 240	2 880	4 460
364	Yellow-Gray Sandy Loam	22 180	2 080	820	540	33 900	4 320	8 420
365	Yellow Sandy Loam	22 180	2 080	820	540	33 900	4 320	8 420
	Deep Loess							
834	Yellow-Gray Silt Loam	16 970	1 750	750	490	34 460	4 400	6 450
835	Yellow Silt Loam	16 510	1 300	870	460	35 750	8 370	6 780
844	Yellow-Gray Fine Sandy Silt Loam	16 960	1 640	700	470	36 710	4 260	6 940
845	Yellow Fine Sandy Silt Loam	15 910	1 710	1 570	470	36 450	10 430	10 160
	Ridge Soils							
234	Yellow-Gray Silt Loam	14 900	1 700	780	400	35 180	4 880	6 340
235	Yellow Silt Loam	15 520	1 340	760	440	39 940	7 560	5 380
	Terrace Soils (1500)							
1544	Yellow-Gray Fine Sandy Silt Loam	18 200	1 920	800	480	36 960	3 940	6 100
1564	Yellow-Gray Sandy Loam	21 480	1 920	740	520	33 100	2 980	8 160
1560.6	Light Brown Sandy Loam	13 700	1 360	620	520	28 980	2 860	7 820
1564.1	Yellow-Gray Sandy Loam On Clay	20 540	1 820	680	720	28 980	3 640	8 740
1534.1	Yellow-Gray Silt Loam On Clay	27 100	2 440	1 280	560	32 820	4 880	7 140
1532	Light Gray Silt Loam On Tight Clay	22 400	1 920	760	500	21 660	5 910	5 680
1516	Gray Clay	27 020	2 380	560	420	30 000	14 540	8 640
1515	Drab Clay	46 580	4 100	1 120	740	31 720	10 980	10 100
	Swamp and Bottom-Land Soils (1300, 1400)							
1331	Deep Gray Silt Loam	24 090	2 470	780	570	32 140	5 820	7 830
1326	Brown Silt Loam	38 240	3 460	1 660	740	37 900	10 900	10 380
1354 1454	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1379	Yellow-Brown Fine Sandy Loam	15 560	1 360	860	540	34 720	4 720	10 560
1363	Mixed Sandy Loam[1]	.....	.....	.....	.....	.....	.....	.....
1315 1415	Drab Clay	50 490	4 360	1 780	850	39 530	16 820	16 070
1426.1	Brown Silt Loam On Clay	59 320	4 500	2 300	880	36 760	11 480	18 600
1428.1	Brown Silt Loam On Tight Clay	33 180	3 040	1 040	660	37 420	8 500	9 680
1426.2	Brown Silt Loam On Sand	32 820	3 040	1 520	780	40 220	13 080	18 280
1460	Brown Sandy Loam	17 920	1 630	1 190	720	33 320	9 390	21 770
1471	Brown Fine Sandy Loam	25 620	2 420	1 080	680	39 160	6 620	11 820
1422.1	Brown-Gray Clay Loam On Tight Clay	49 460	3 900	1 340	700	33 320	10 360	12 000
	Residual Soils (000)							
098	Stony Loam	34 800	2 720	1 040	500	28 300	9 280	51 180
099	Rock Outcrop, Limestone, Sandstone	.....	.....	.....	.....	.....	.....	.....

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]On account of the heterogeneous character of Mixed Loams, chemical analyses are not included for these types.

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF RANDOLPH COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300)							
330	Gray Silt Loam On Tight Clay	34 150	2 670	1 240	1 030	49 910	15 680	10 290
328	Brown-Gray Silt Loam On Tight Clay	44 920	3 120	1 480	760	59 360	15 280	16 200
	Upland Timber Soils (200, 300, 800)							
	Shallow Loess							
334	Yellow-Gray Silt Loam	20 090	1 950	1 340	740	59 030	16 850	9 620
335	Yellow Silt Loam	22 240	2 200	1 480	600	69 160	23 920	20 080
332	Light Gray Silt Loam On Tight Clay	16 200	1 040	720	600	54 240	10 520	9 160
364	Yellow-Gray Sandy Loam	21 760	2 280	1 480	720	73 520	11 480	15 360
365	Yellow Sandy Loam	21 760	2 280	1 480	720	73 520	11 480	15 360
	Deep Loess							
834	Yellow-Gray Silt Loam	19 610	2 370	1 820	770	75 940	14 890	12 490
835	Yellow Silt Loam	17 990	1 370	2 010	770	69 410	21 480	15 540
844	Yellow-Gray Fine Sandy Silt Loam	19 860	2 260	2 200	740	78 700	16 260	15 140
845	Yellow Fine Sandy Silt Loam	15 040	2 040	2 780	640	74 220	21 800	23 140
	Ridge Soils							
234	Yellow-Gray Silt Loam	19 990	2 400	1 720	520	74 280	18 480	12 320
235	Yellow Silt Loam	20 480	1 760	1 920	800	74 880	20 560	10 760
	Terrace Soils (1500)							
1544	Yellow-Gray Fine Sandy Silt Loam	20 360	2 220	1 720	680	78 320	13 560	12 960
1564	Yellow-Gray Sandy Loam	15 320	1 440	1 040	600	66 840	7 770	15 680
1560.6	Light Brown Sandy Loam	15 000	1 600	1 080	920	61 960	7 120	16 000
1564.1	Yellow-Gray Sandy Loam On Clay	18 520	2 000	880	1 080	61 960	12 120	16 640
1534.1	Yellow-Gray Silt Loam On Clay	18 480	2 120	1 960	880	69 440	12 320	12 560
1532	Light Gray Silt Loam On Tight Clay	21 840	2 400	1 040	840	47 400	14 800	14 760
1516	Gray Clay	25 880	3 280	880	800	58 160	47 560	43 000
1515	Drab Clay	58 400	5 160	1 600	960	63 600	23 320	18 160
	Swamp and Bottom-Land Soils (1300, 1400)							
1331	Deep Gray Silt Loam	31 260	3 680	1 380	920	64 400	9 880	14 480
1326	Brown Silt Loam	52 200	5 000	2 640	1 080	74 440	19 960	21 280
1354 1454	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1379	Yellow-Brown Fine Sandy Loam	32 360	2 880	1 920	880	65 880	10 760	22 880
1363	Mixed Sandy Loam[1]	.....	.....	.....	.....	.....	.....	.....
1315 1415	Drab Clay	55 950	5 770	2 960	1 030	78 190	36 520	30 550
1426.1	Brown Silt Loam On Clay	96 360	7 160	3 200	1 520	75 760	24 800	36 200
1428.1	Brown Silt Loam On Tight Clay	40 280	4 160	1 440	920	73 280	23 080	20 360
1426.2	Brown Silt Loam On Sand	43 560	4 680	2 640	1 440	78 400	25 920	36 960
1460	Brown Sandy Loam	22 140	1 860	2 180	1 280	65 540	22 120	54 720
1471	Brown Fine Sandy Loam	47 360	3 920	2 160	1 080	79 680	18 720	25 320
1422.1	Brown-Gray Clay Loam On Tight Clay	58 440	4 520	1 760	1 200	68 440	30 240	23 320
	Residual Soils (000)							
098	Stony Loam[2]	.....	.....	.....	.....	.....	.....	.....
099	Rock Outcrop, Limestone, Sandstone	.....	.....	.....	.....	.....	.....	.....

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of Mixed Loams, chemical analyses are not included for these types.

[2]No samples could be taken of this type because of the stony condition.

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF RANDOLPH COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES
Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300)							
330	Gray Silt Loam On Tight Clay	29 300	2 860	2 960	1 180	88 900	40 120	27 460
328	Brown-Gray Silt Loam On Tight Clay	30 600	1 920	3 660	840	93 420	37 560	34 320
	Upland Timber Soils (200, 300, 800)							
	Shallow Loess							
334	Yellow-Gray Silt Loam	21 050	1 900	3 060	920	94 310	37 410	20 120
335	Yellow Silt Loam	20 460	2 640	1 980	1 020	101 880	34 800	33 600
332	Light Gray Silt Loam On Tight Clay	27 120	2 040	2 940	1 140	89 280	35 820	19 680
364	Yellow-Gray Sandy Loam	24 780	2 280	3 840	960	110 940	35 340	22 500
365	Yellow Sandy Loam	24 780	2 280	3 840	960	110 940	35 340	22 500
	Deep Loess							
834	Yellow-Gray Silt Loam	21 540	2 940	3 680	1 020	108 150	33 650	18 750
835	Yellow Silt Loam	20 540	2 070	2 840	1 010	111 870	32 480	30 260
844	Yellow-Gray Fine Sandy Silt Loam	22 200	2 610	4 050	1 140	112 500	33 360	24 330
845	Yellow Fine Sandy Silt Loam	18 490	2 010	3 540	720	114 810	34 050	47 400
	Ridge Soils							
234	Yellow-Gray Silt Loam	26 280	3 360	3 060	840	104 580	36 960	19 860
235	Yellow Silt Loam	19 320	1 920	2 040	900	102 120	27 360	19 200
	Terrace Soils (1500)							
1544	Yellow-Gray Fine Sandy Silt Loam	19 140	2 420	3 780	900	124 320	33 180	19 680
1564	Yellow-Gray Sandy Loam	16 200	1 860	2 940	900	98 100	21 180	26 280
1560.6	Light Brown Sandy Loam	19 260	2 160	2 100	1 500	89 340	16 200	25 800
1564.1	Yellow-Gray Sandy Loam On Clay	22 560	2 940	2 160	1 200	97 860	36 960	26 580
1534.1	Yellow-Gray Silt Loam On Clay	16 620	2 880	3 360	780	95 220	40 380	17 340
1532	Light Gray Silt Loam On Tight Clay	31 980	3 360	1 920	840	68 640	43 920	27 420
1516	Gray Clay	25 980	3 540	2 400	1 980	95 100	100 620	179 700
1515	Drab Clay	36 720	4 500	1 500	960	95 940	47 640	27 780
	Swamp and Bottom-Land Soils (1300, 1400)							
1331	Deep Gray Silt Loam	24 900	3 720	1 830	1 260	93 210	14 340	17 490
1326	Brown Silt Loam	70 980	7 320	4 080	1 620	111 840	31 380	33 000
1354 1454	Mixed Loam[1]							
1379	Yellow-Brown Fine Sandy Loam	50 160	4 680	2 700	1 260	94 740	18 660	32 880
1363	Mixed Sandy Loam[1]							
1315 1415	Drab Clay	47 200	5 240	3 980	1 380	120 180	55 860	48 460
1426.1	Brown Silt Loam On Clay	89 580	7 800	3 420	1 500	119 220	59 040	44 640
1428.1	Brown Silt Loam On Tight Clay	38 400	4 080	2 520	1 140	96 660	38 580	29 340
1426.2	Brown Silt Loam On Sand	29 160	3 660	3 420	1 260	117 180	27 540	57 900
1460	Brown Sandy Loam	24 150	2 160	3 300	1 200	102 540	35 940	93 150
1471	Brown Fine Sandy Loam	39 540	4 140	3 480	1 440	114 480	38 520	36 420
1422.1	Brown-Gray Clay Loam On Tight Clay	64 200	5 100	2 160	1 140	88 500	60 480	37 080
	Residual Soils (000)							
098	Stony Loam[2]							
099	Rock Outcrop, Limestone, Sandstone							

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of Mixed Loams, chemical analyses are not included for these types. [2]The stony condition of the subsoil precluded the taking of samples.

It is not intended to imply by the above statements that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for factors other than the amount of plant-food elements present in the soil enter into consideration. Much depends upon the nature of the crops to be grown as to their ability to utilize plant-food materials, and much depends upon the condition of the plant-food substances themselves as to their availability. Finally, in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon, and in this way contribute information that is fundamental if we are to plan intelligently, and in a broad way, systems of soil management that will conserve and improve the fertility of the land.

DESCRIPTION OF SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Randolph county cover only 41.11 square miles, or a little less than 7 percent of the area of the county. The two soils included in this group have a "tight clay" subsoil which interferes seriously with underdrainage. Both types occupy flat areas.

Gray Silt Loam On Tight Clay (330)

Gray Silt Loam On Tight Clay covers somewhat over two-thirds of the prairie area of the county. The type is very uniform except that the areas which are near the broken, hilly belt adjacent to Mississippi river contain more fine sand than those areas that lie north and northeast of Sparta.

The surface soil varies from 7 to 8 inches in depth and is a gray or light brownish gray silt loam. The subsurface, which is a gray silt loam or a gray fine sandy silt loam, extends to a depth of 15 to 18 inches. The subsoil is made up of two strata, the upper, a strongly mottled yellow or dark reddish brown plastic clay, the lower, a friable, strongly mottled yellow silt loam.

Management.—The acidity of this type, according to the tests made, varies from slight to strong in the surface and subsurface. The subsoil ordinarily shows no acidity, altho carbonates are not present. The great variation in the lime requirement of this type makes it advisable to test each field which is to be limed, as directed in the Appendix, page 34, or better, with the assistance of the county farm adviser or of the Experiment Station. The chief difficulty in the management of this type is poor drainage. The impervious subsoil makes it necessary to depend on surface drainage, and this method of removing surplus water is not entirely satisfactory. The amounts of organic matter and nitrogen in the soil are low, and special effort should be made to increase these constituents by growing legumes, preferably sweet clover.

The problem of phosphate fertilization has not been finally worked out for this soil type. The evidence thus far secured from the experiment fields in southern Illinois is in agreement in showing that the use of rock phosphate at

the rate of one ton an acre for a rotation does not result in sufficient increase in crop yields to pay for the phosphate. Altho, by the rock-phosphate treatment, the wheat yield was increased 4.5 bushels in the manure system and 4.0 bushels in the residue system, as an average of 30 crops on four fields, these increases are not large enough (in the absence of any consistent increases in the yields of the other crops in the rotation) to pay for the cost of the rock phosphate. Steamed bone meal has been used at the rate of 200 pounds an acre a year on three experiment fields in southern Illinois which are located on this soil type. This treatment has resulted in a fair profit on the DuBois field, but in a consistent loss on the Cutler and Odin fields. One series of plots on the Odin field has been used for a study of the comparative effect of steamed bone meal, acid phosphate, rock phosphate, and slag phosphate on crop yields, in a rotation of corn, oats, and three years of clover and timothy hay. These materials are applied at the rate of 200, 333, 666, and 260 pounds an acre a year respectively. In these experiments the increase in yield has in no case been large enough to pay for the cost of the phosphate.

The results, thus briefly stated, following the use of the various phosphates should not be interpreted to mean that none of the above phosphates can be used at a profit on this soil, but rather that none of them can be used at a profit *as they were used in these experiments.* The character of this soil, together with the well-known response of wheat to phosphates, suggests that further trials be made of phosphatic fertilizers, altho with the present information no definite recommendation as to the particular form of phosphorus carrier to use can be given. If either acid phosphate or basic slag is used, it should be applied at the rate of about 300 pounds an acre after plowing and before working down the seed bed. Rock phosphate should be applied in larger amounts, probably about 1,000 pounds an acre. It should be applied either in preparation for a clover crop, or turned down with some form of organic matter as explained in the Appendix, page 37.

The marked response exhibited by corn to potassium fertilization on this soil prompts the further suggestion that trials of potash be made, at least on an experimental scale, the material being applied direct to the corn crop. For this purpose a dressing of either potassium sulfate or potassium chlorid at the rate of 100 pounds an acre may be given the land in preparation for corn.

These suggestions presuppose that sufficient nitrogen is supplied for good crop yields thru the growing of legumes and the use of manure and crop residues. It should be noted that the experiment field results at Odin and at DuBois, which are included in the Supplement, pages 50 and 55, show a very substantial and profitable increase in yields on this soil following the use of limestone and some form of organic matter, either farm manure, green manures, or crop residues. The reader is referred to the Supplement of this report for results secured on certain of the experiment fields in the southern part of the state which are located on this soil type.

Brown-Gray Silt Loam On Tight Clay (328)

Brown-Gray Silt Loam On Tight Clay covers only 12.78 square miles, or 2.15 percent of the area of the county. It occurs, for the most part, in the vicinity of the village of Baldwin.

The surface is about 8 inches deep and is a grayish brown silt loam. The subsurface is a light gray silt loam and usually extends to a depth of about 20 inches. Occasionally this gray layer is found to consist of two strata, the upper being a brownish gray silt loam which passes into the true gray layer at a depth of about 13 inches. The subsoil is made up of two strata: the upper, to a depth of 32 to 36 inches, is a plastic, strongly mottled yellow or dark reddish brown clay; the lower is a friable, mottled yellow silt loam or silty clay loam frequently containing numerous dark red spots or blotches of iron oxid.

Management.—Tests show this type to be of medium acidity to the depth of the lower subsoil stratum, except in the case of the scald spots, which commonly contain lime concretions at a depth of 20 to 30 inches. Below the subsoil it is either not acid or only slightly so. No carbonates were found to a depth of 5 feet, except as above noted. Limestone should be applied at the rate of 2 or 3 tons an acre. It is advisable to test each field which is to be limed, as directed on page 34 of the Appendix, or better, with the assistance of the county farm adviser or of the Experiment Station, in order to determine the amount of limestone needed. The flat topography of the type, together with its impervious upper subsoil stratum, makes drainage the most serious difficulty in its management. Surface drainage must be depended upon for the removal of excess water since the impervious nature of the subsoil or "tight clay" makes the downward movement of water very slow. The amounts of nitrogen and organic-matter in the type are low, and these deficiencies should be met by growing legumes, preferably sweet clover, and using them for soil improvement either directly as green manures or indirectly as stable manure. The roots of sweet clover penetrate the "tight clay," and thus make use of the nutrient elements contained in it. Whether their penetration and subsequent decay will result in gradually opening up this relatively impervious stratum is not yet established.

There is not enough experimental evidence regarding the fertilization of this soil type to warrant a definite statement. Nitrogen is probably the limiting factor, and until this deficiency is met by the use of clovers, as advised above, the application of mineral fertilizers could not be expected to cause satisfactory increases in yield. The evidence thus far secured from the experiment fields indicates that rock phosphate cannot be used at a profit when applied at the rate of a ton an acre every four or five years; there is, of course the possibility that a lower rate of application might prove profitable. The possibility also suggests itself that the use of one of the more soluble phosphates, either acid phosphate or basic slag, for wheat might prove profitable. For a more complete discussion of the phosphate problem and advice as to how to apply the more soluble phosphates, the reader is referred to the recommendations for the management of Gray Silt Loam On Tight Clay (330), page 13. A suggestion will also be found on this same page regarding the trial of a potash fertilizer for corn. Results of experiments on the Alhambra and the Pana fields, representing Brown-Gray Silt Loam On Tight Clay, are reported in the Supplement, pages 57 and 58.

(b) UPLAND TIMBER SOILS

Yellow-Gray Silt Loam, Shallow Loess (334)

Yellow-Gray Silt Loam, Shallow Loess, is the most extensive soil type in Randolph county. It covers an area of 168.02 square miles, or about 28 percent of the area of the county. The type varies in topography from flat to gently rolling. The flat portions of the type have a compact subsoil which approaches the prairie subsoil in tightness; the undulating and rolling portions of the type have a subsoil which, tho frequently compact, is not impervious. The tendency towards tightness or imperviousness is characteristic of the more level areas of Yellow-Gray Silt Loam in southern Illinois. Another characteristic of the type as a whole in the southern part of the state is the presence of so-called scald spots.

The surface soil of this type varies in depth from 7 to 8 inches, in color from a light brownish gray to a yellowish gray, and in texture from a silt loam to a fine sandy silt loam. The subsurface varies from 14 to 20 inches in depth and is usually a light gray silt loam on the flat areas and a yellowish gray silt loam on the undulating areas. The subsoil appears to be made up of two strata. The upper is a mottled yellow, impervious clay on the flat areas and a mottled yellow, compact but not impervious, clay loam or silty clay loam on the undulating areas. The depth of this stratum varies from 30 to 38 inches. The lower subsoil stratum is a mottled yellow or reddish yellow, friable silty clay loam.

Management.—This type varies from medium to strongly acid. No carbonates occur to a depth of five feet, tho the reaction is usually neutral or only slightly acid below a depth of 40 inches. Careful tests should be made of each field before liming, as directed in the Appendix, page 34, or better, with the assistance of the county farm adviser or of the Experiment Station. Surface drainage is good except on the flat areas and, unfortunately, the tendency to "tightness" of the subsoil on these flat areas make surface drainage by means of furrows necessary. The organic-matter and nitrogen contents of the soil are low. The results of field experiments in southern Illinois are in agreement in showing that the use of limestone and clover or farm manure is very profitable on this soil type. The results from these same fields are likewise in agreement that rock phosphate cannot be used at a profit at the rate at which it has been applied on these fields; that is, at the rate of one ton an acre once in the rotation. No experimental information is available as to whether it can be used in smaller amounts at a profit; however, this is a possibility which is well worth trying in an experimental way. It is also suggested that one of the more soluble phosphates, either acid phosphate or basic slag, be tried as suggested for Gray Silt Loam On Tight Clay (see page 13). It would also be well to try potash for corn, as suggested in this same discussion.

Yellow Silt Loam, Shallow Loess (335)

Yellow Silt Loam, Shallow Loess, occupies 50.9 square miles, or 8.41 percent of the area of the county. It is of low agricultural value because of its steep topography, and is, for the most part, suited only to pasture and timber.

The character of this type varies greatly owing to differences in rate of erosion caused chiefly by differences in slope. The surface soil is usually a yellow

or grayish yellow silt loam. It may be a yellow or grayish yellow clay loam, depending on the amount of recent erosion. The subsurface and subsoil are similar to the surface in color but are heavier and are compact.

Management.—Leaching has removed the carbonates from this type to a depth greater than that to which roots can penetrate. This fact may explain why bluegrass does not do well over much of the area. The steep slopes make the land subject to serious washing. If limestone can be secured, both of the above difficulties can be met, but much of this land is too far from a shipping point to permit the purchase of limestone, and much of it is too steep for the profitable application of this material. Under such conditions it would seem that the land should be used for timber production. In case limestone can be considered, the reader is referred to the discussion of the Vienna experiment field in the Supplement, page 61.

Light Gray Silt Loam On Tight Clay, Shallow Loess (332)

Light Gray Silt Loam On Tight Clay, Shallow Loess, occurs in small flat areas thruout Yellow-Gray Silt Loam (334). It is the poorest type of upland soil in the county, but fortunately there is a total of only 3.54 square miles of it.

The surface is a gray silt loam or fine sandy silt loam and is about 6 inches deep. The subsurface is usually light gray to nearly white silt loam and passes very abruptly into the subsoil at a depth of about 20 inches. The subsoil comprizes two strata. The upper stratum is a very plastic, strongly mottled yellow or gray clay; the lower, starting at about 34 inches, is a friable, gray or strongly mottled silt loam.

Management.—The impervious subsoil of this type makes underdrainage impossible. The soil is strongly acid and very low in organic matter. Sweet clover will do well after about 4 tons of limestone an acre has been applied. Timothy and redtop are probably the surest crops on this land. See page 44 of the Supplement for an account of field experiments on this type of soil.

Yellow-Gray Sandy Loam, Shallow Loess (364)

Yellow-Gray Sandy Loam, Shallow Loess, occurs as long, narrow strips adjacent to the bottom land or terrace of Kaskaskia river. Only 1.1 square miles of the type are found in the county.

The surface is a light brown or yellowish brown fine sandy loam. The subsurface, beginning at about 7 inches, is a yellowish gray fine sandy loam, and the subsoil, beginning at about 16 inches, is a dark reddish yellow, silty clay loam. At a depth of about 37 inches, the subsoil becomes fairly friable and mottling appears. There is, however, no very distinct difference between these two subsoil strata.

Management.—Limestone should be applied at the rate of 2 to 3 tons an acre and clovers grown to provide nitrogen and to help increase the organic-matter content of the soil. The trial of one of the soluble phosphates, either acid phosphate or basic slag, for wheat, and a potash salt for corn is suggested. The method and rate of application of these fertilizing materials is explained in the discussion of the management of Gray Silt Loam On Tight Clay, page 13.

Yellow Sandy Loam, Shallow Loess (365)

Yellow Sandy Loam is of little importance because of its small area (.64 square mile) and its low agricultural value. The surface is a yellow sandy loam unless very recent erosion has exposed the deeper strata. The subsurface and subsoil are similar to the surface except that they are compact.

Management.—The reader is referred to the discussion of the management of Yellow Silt Loam (335), page 16, for suggestions regarding the management of this type.

Yellow-Gray Silt Loam, Deep Loess (834)

Yellow-Gray Silt Loam, Deep Loess, occurs on the narrow divides in the rough, hilly belt adjacent to the Mississippi river. It usually contains a higher percentage of fine sand than those areas of timber soil which are farther from the river. The profile of this type is similar to that of the rolling portions of Yellow-Gray Silt Loam, Shallow Loess (334).

The surface soil, which is 7 to 9 inches in depth, is a yellowish brown, fine sandy silt loam or silt loam. The subsurface to a depth of 18 or 20 inches is a slightly mottled, yellowish gray, fine sandy silt loam. The subsoil to a depth of about 32 inches is a mottled, yellow, silty clay loam, with a very decided compactness on the more level portions of the area which are adjacent to the line separating the shallow from the deep loess. Below 32 inches, the subsoil is a friable, mottled yellow silt loam.

Management.—The management requirements of this type are the same as those for Yellow-Gray Silt Loam, Shallow Loess, (see page 16), with the exception that less limestone is probably required, particularly near the bluff line.

Yellow Silt Loam, Deep Loess (835)

Yellow Silt Loam, Deep Loess, is similar to the corresponding shallow loess type with the following exceptions: it contains a higher percentage of fine sand, the slopes are longer and frequently steeper, and less limestone is probably required to grow clover. The tests made did not show carbonates to be present in the 5-foot section, and the absence of sweet clover growing wild in cuts indicates deep leaching of the carbonates; however, a lower degree of acidity was indicated by the acidity tests than was found to prevail in the shallow loess area. This type covers an area of about 61 square miles, or a little more than 10 per cent of the area of the county.

Management.—Yellow Silt Loam, Deep Loess, should be used for orchards, pasture, or timber. The slopes are too long and too steep, as a rule, to permit the raising of cultivated crops. Clover can rarely be grown with any degree of success without limestone, and the roads are such as to prohibit its application if it has to be hauled from a shipping point. The problem may be solved by local crushing or home burning where a limestone outcrop is available.

Yellow-Gray Fine Sandy Silt Loam, Deep Loess (844)

Yellow-Gray Fine Sandy Silt Loam, Deep Loess, (844) is very similar to Yellow-Gray Silt Loam (834); in fact, the line separating the two is very in-

definite. The former type contains a higher percentage of fine sand than the major portion of the latter type; however, the proportion of fine sand decreases gradually from the river inland. The type occupies an area of 16.6 square miles, or 2.8 percent of the area of the county.

The surface soil is about 8 inches deep and is a grayish yellow fine sandy loam. The subsurface, extending to a depth of about 19 inches, is a pale yellow fine sandy loam. The subsoil is made up of two distinguishable strata; the upper to a depth of about 45 inches is a compact, slightly mottled, yellow silty clay loam; the lower is very similar in color and physical composition but is much less compact.

Management.—Since this type occurs on the crests of the narrow divides, the fields are narrow and irregular in outline. The soil is acid, tho not strongly so. The carbonates have been leached out to a depth of at least 5 feet. The fact that sweet clover is rarely found growing wild in the cuts indicates an advanced stage of leaching. The most important consideration in the management of this soil is to increase its nitrogen and organic-matter contents by the use of clover. It is necessary to make a moderate application of limestone in order to grow clover. The exact amount needed varies in different portions of the area, but in general, 2 tons an acre, if finely ground, will be sufficient to get a good stand of clover. It is not probable that this type will respond to rock phosphate very satisfactorily. The Unionville experiment field is located on soil that is similar, and the returns on that field are not such as to encourage the use of this material. The information which is now available indicates that if this land is to be used for growing the general farm crops, nitrogen and organic matter should be provided as advised above, and that in addition to this, one of the soluble phosphates, either acid phosphate or basic slag, should be tried for wheat, applying it after plowing and before working down the seed bed, at the rate of about 300 pounds an acre. It is also suggested that a trial be made of one of the potash salts, applying it at the rate of about 100 pounds an acre for corn, after plowing.

Yellow Fine Sandy Silt Loam, Deep Loess (845)

Yellow Fine Sandy Silt Loam is similar to Yellow Silt Loam (835) in topography; in character of soil, except that it contains a larger proportion of fine sand; in agricultural value; in degree of acidity; and in lack of carbonates to a depth of 5 feet.

Management.—The reader is referred to the discussion of the management of Yellow Silt Loam (835), page 18, for suggestions regarding the management of this type.

Yellow-Gray Silt Loam, Ridge (234)

Yellow-Gray Silt Loam, Ridge, occupies a very distinct morainal ridge which extends northward from the vicinity of Steeleville to about a mile from Sparta and takes a westerly direction to Plum creek. The slopes are strongly eroded owing more to lack of care in protecting them against washing than to their steepness.

The surface soil is a grayish yellow silt loam and is about 7 inches deep. The subsurface is a gray silt loam, and the subsoil, starting at about 20 inches, is a compact, mottled, yellow clay loam to a depth of about 35 inches, where it becomes friable.

Management.—This type requires practically the same management as Yellow-Gray Silt Loam (334), page 16, and in addition special precautions should be taken to control washing.

Yellow Silt Loam, Ridge (235)

Yellow Silt Loam, Ridge, was separated in the mapping from Yellow Silt Loam, Shallow Loess, on the basis of difference in formation. The two types are similar in character of soil, with the difference that the slopes of the ridge type are less steep, as a rule, than those of the shallow loess type; so far as is known, they require the same kind of management.

(c) TERRACE SOILS

Yellow-Gray Fine Sandy Silt Loam (1544)

Yellow-Gray Fine Sandy Silt Loam, Terrace, is limited almost entirely to small, disconnected areas bordering the lower course of Mary's creek. It is an unimportant type because of its small extent, .75 square mile. It occupies areas which are about 40 feet above the level of the adjacent bottom lands. These areas apparently are old formations. Some of them have a subsoil which has a tendency to be impervious, or "tight."

The surface soil, to a depth of about 7 inches, is a gray or yellowish gray, fine sandy silt loam. The subsurface varies from a mottled yellow silt loam to a gray silt loam, depending on whether a tight clay subsoil has been formed. A gray subsurface is associated with a tight subsoil. The subsoil, beginning at about 19 inches, when not tight is a compact, mottled, yellow clay loam, which becomes friable at about 35 inches. The same colors and depths are found on the tight areas, but the highly plastic, impervious nature of the tight layer has a marked influence on agricultural value.

Management.—The reader is referred to the discussion of the management of Yellow-Gray Fine Sandy Silt Loam (844), page 18, for suggestions regarding the management of this type. The requirements of the two types are probably the same, with the exceptions that a somewhat heavier application of limestone should be made to the terrace type and provision for surface drainage of the portions of the type having an impervious subsoil should be made.

Yellow-Gray Sandy Loam (1564)

Yellow-Gray Sandy Loam, Terrace, covers an area of about 2 square miles. It occurs, for the most part, adjacent to the bottom land of Kaskaskia river south of the village of Evansville. The areas west of the river are 20 feet or more above the level of the bottom land, while those east of the river are only a few feet above it.

This type differs from Yellow-Gray Sandy Loam, Upland (364), in its method of formation but is similar in other respects, including management requirements. For suggestions regarding the management of this type, the reader is referred to the discussion of the management of Yellow-Gray Sandy Loam, Upland, page 17.

Light Brown Sandy Loam (1560.6)

There is less than half a square mile of Light Brown Sandy Loam in Randolph county. This type occurs along the lower course of Kaskaskia river.

The surface is a light brown or grayish brown sandy loam. The subsurface, beginning at about 8 inches, is a grayish yellow sandy loam, and the subsoil is a mottled, yellow, compact, sandy clay loam.

Management.—This type has the same general management requirements as Yellow-Gray Sandy Loam, Upland, and the reader is referred to the management discussion found on page 17.

Yellow-Gray Sandy Loam On Clay (1564.1)

Yellow-Gray Sandy Loam On Clay occurs in small areas along the lower courses of Mary's creek and Kaskaskia river. Its total area is less than one square mile.

The surface, which is about 8 inches deep, is a brownish gray sandy loam. The subsurface is a gray sandy loam, and the subsoil, beginning at about 20 inches, is a plastic but pervious gray clay or clay loam.

Management.—Yellow-Gray Sandy Loam On Clay probably has the same management requirements as Yellow-Gray Sandy Loam (364), with the exception that its drainage is poorer. The reader is referred to the discussion on page 17 for suggestions regarding the management of this type.

Yellow-Gray Silt Loam On Clay (1534.1)

Yellow-Gray Silt Loam On Clay is found along Mary's, Butter, and Plum creeks, and Kaskaskia river, and has the same character of profile as the preceding type, Yellow-Gray Sandy Loam On Clay, with the exception that the surface and subsurface are silt loam. It occupies an area of little more than 2 square miles.

Management.—The reader is referred to the management paragraph for Yellow-Gray Silt Loam (334), page 16, for suggestions regarding the management of this type.

Light Gray Silt Loam On Tight Clay (1532)

Light Gray Silt Loam On Tight Clay, Terrace, occurs in small detached areas bordering nearly all the streams in the county. The total area of the type is only 4.14 square miles and this fact, together with its low agricultural value, makes it an unimportant type. It is similar in topography, character of profile, and management requirements to the corresponding upland type and differs from it only in origin.

Gray Clay (1516)

Gray Clay, Terrace, is found along the lower course of Kaskaskia river just south of Evansville. It occupies only 1.15 square miles and is of small importance. The surface soil is gray clay, plastic and difficult to work. There is no distinct stratification showing subsurface and subsoil development, but the color becomes a lighter gray and the degree of plasticity increases with increasing depth.

Management.—Gray Clay is not well suited to farming because its physical characteristics make it extremely difficult to work. Portions of the type are farmed. Post oak is the characteristic timber found on the type, and probably the entire area should be used for timber production.

Drab Clay (1515)

Drab Clay, Terrace, is found in small areas along the lower course of Kaskaskia river. Its total area in the county is less than one square mile.

This type is similar to Gray Clay (1516), described above. It differs from Gray Clay in that its color thruout the 40-inch section is drab instead of gray and it is slightly less plastic.

(d, e) SWAMP AND BOTTOM-LAND SOILS (1300, 1400)

It has been found advisable to abandon the classification of swamp and bottom-land soils into the two groups "Old" and "Late" as shown on the map (which was made in 1916-17), because this classification was based on the supposed age of the soil material and not on the stage of maturity of the soil. The difficulty which arises in attempting to adhere to this classification is well illustrated by the following example taken from Randolph county. Yellow-Brown Fine Sandy Loam (1379) is classified in the "Old" group. This type consists of a recent deposit from the adjacent bluffs and lies on top of surrounding types which are classified as "Young" or "Late." This deposit is so recent that none of the characteristics of mature soils have been developed. This brief discussion is intended to clear up the question which might arise as to the reason for not adhering in the type descriptions to the grouping of bottom-land types which appears on the soil map.

Deep Gray Silt Loam (1331)

Deep Gray Silt Loam, Bottom, comprizes the major portion of the small bottoms thruout the county. Its total area is 24.44 square miles.

The surface soil is about 7 inches deep and is a light brownish gray silt loam. Distinct subsurface and subsoil horizons are not usually found to have been developed. Over a considerable portion of the type a gray fine sandy silt loam subsurface is found extending to a depth of about 30 inches, and then a strongly mottled, chocolate-colored, fine sandy silt loam subsoil, which is not plastic and only slightly compact, occurs.

Management.—This type varies in acidity from slight to strong, tho but a small portion of it shows a high lime requirement because of frequent overflows which tend to keep the acidity neutralized. A large percentage of the type

is under cultivation. It is well adapted to corn growing but, because of flooding, the maintaining of the nitrogen and organic-matter supply is peculiarly difficult. Wherever clover can be grown, the lime requirement should be satisfied. On account of extreme difficulties in transportation in much of this district, the use of burned lime instead of limestone, as representing a more concentrated product, might be considered in some cases. Clover should then be grown systematically, for this soil is very low in nitrogen and organic matter.

Brown Silt Loam (1326)

Brown Silt Loam, Bottom, is found along Kaskaskia river, and covers a total area of only 3.25 square miles. It is a recent soil, as shown by the absence of horizon development. The surface to a depth of about 12 inches is brown silt loam. At this depth the color changes to drabbish brown with slight mottling.

Management.—This type is usually medium acid and requires 2 or 3 tons of limestone an acre to grow sweet clover. It is a fertile soil, well adapted to clover growing, but is subject to overflow, thus largely eliminating the possibility of growing clover as a means of maintaining the organic-matter and nitrogen supply. No fertilizer application is advised for this type, but it is suggested that every means available for maintaining the organic-matter content of the soil be utilized.

Mixed Loam (1354, 1454)

Mixed Loam is found in the bottoms along the upper courses of the small streams thruout the county and in the Mississippi bottom. It occupies a total area of 50.67 square miles. Much of this land is subject to frequent flooding and, while it is productive, it must be used for crops which can be planted and harvested between flood periods. Much of this type is occupied by timber. The timber growth consists of sycamore, maple, elm, hickory, oak, and other varieties. The areas classified as Mixed Loam consist of a variety of soils which cannot successfully be separated. Some of this land is under cultivation and much of it would be well adapted to general farming were it not for frequent flooding.

Yellow-Brown Fine Sandy Loam (1379)

Yellow-Brown Fine Sandy Loam, Bottom, occupies an area of 5.19 square miles. It consists of a deposit of wash derived from the adjacent bluffs and it varies considerably in depth. The underlying soil upon which it has been deposited is frequently encountered within the 40-inch section. The deposit is so recent that but slight horizon development has taken place.

The surface to a depth of 9 or 10 inches is yellowish brown fine sandy loam and below this, down to the underlying soil upon which the deposit has been made, it is grayish yellow in color and is of the same texture as the surface.

Management.—This soil shows no acidity and is productive and easily worked. It is an excellent alfalfa soil and is well adapted to general farming or to vegetable growing. No fertilizer treatment is advised for this type, but it is recommended that every means available for increasing its nitrogen and organic-matter supply be utilized.

Mixed Sandy Loam (1363)

Mixed Sandy Loam occupies less than half a square mile. It is similar to Mixed Loam except that its texture is coarser and, in general, is not so good a soil as Mixed Loam because of its coarse texture.

Drab Clay (1315, 1415)

There are almost 20 square miles of Drab Clay, Bottom, mapped in Randolph county, most of which is in the Mississippi bottom. This type has a dark, drab-colored surface soil to a depth of about 8 inches, and is drab-colored below 8 inches. The texture is clay thruout the soil section and dark reddish yellow splotches begin to occur at a depth of about 16 inches.

Management.—Much of the Drab Clay in subject to overflow and is poorly drained. It is farmed to some extent, tho a considerable portion of it is in timber. Its heavy nature and high plasticity makes it an undesirable soil for farming even tho it were drained. The chief requirement in the management of this type, after drainage, is fresh organic matter. It is but slightly acid, even where infrequently flooded, and the frequently flooded portions of the type show no acidity.

Brown Silt Loam On Clay (1426.1)

Brown Silt Loam On Clay, Bottom, has a total area of 10.12 square miles. It is a productive soil, tho inadequately drained.

The surface soil, which is usually about 9 inches deep, is brown silt loam, frequently a heavy phase. In some portions of the area the subsurface, 9 to 18 inches, is grayish brown silt loam, while in others this stratum is black clay which rests on drab clay at a depth of about 18 or 19 inches. In case the grayish brown stratum is present, it usually rests on a thin stratum of black clay and the drab clay occurs at a depth of about 26 inches instead of at 18 or 19 inches as in the former case.

Management.—There is need for better drainage over most of the area occupied by this type. The reaction varies from neutral to slightly acid. In no case would more than 2 tons of limestone an acre be needed for sweet clover or alfalfa. Provision should be made for adding organic matter at regular intervals. No soil treatment other than good tillage, fresh organic matter, and limestone where needed, is advised.

Brown Silt Loam On Tight Clay (1428.1)

Brown Silt Loam On Tight Clay occurs in small areas in the Mississippi bottom between Fort Gage and Prairie du Rocher. The total area of this type in Randolph county is about 1½ square miles.

The surface soil, which is about 7 inches deep, is brown silt loam. The subsurface is usually a thin stratum of only 3 or 4 inches in thickness. It is grayish brown silty clay loam. The upper subsoil which extends to a depth of about 28 or 30 inches is a mottled, brown and yellow clay loam, fairly compact and plastic. The lower subsoil is a very friable, mottled, yellow sandy silt loam.

Management.—This type is in need of better drainage. The presence of a rather impervious subsoil makes it necessary to depend entirely on open ditches for the removal of excess water. The surface and subsurface are not acid and the subsoil shows only slight or medium acidity. No treatment is advised for this soil other than improving the drainage and providing for the regular return of organic matter.

Brown Silt Loam On Sand (1426.2)

Brown Silt Loam On Sand occurs mainly on Kaskaskia Island. A total of 5.92 square miles was mapped. Its peculiar formation in long narrow strips between depressions of Drab Clay (1415) or Brown Sandy Loam (1460) is due to river action. The depth to sand varies from 5 or 6 inches to about 30 inches.

The surface soil is brown silt loam and is about 8 inches deep, where the sand does not occur within that distance below the surface. Below the surface soil down to the sand is a drabbish brown silt loam.

Management.—This soil, where not subject to too frequent overflow, is excellent alfalfa land and is equally good for any of the general farm crops. It is not acid and requires only good tillage and fresh supplies of organic matter to keep it in excellent condition.

Brown Sandy Loam (1460)

Brown Sandy Loam, Bottom, occurs, for the most part, as long narrow ridges of sand-bar like formation. A total of 8.56 square miles is found in the county, and all of it is located in the Mississippi bottom and on Kaskaskia Island. It varies from a good productive sandy loam to coarse sand. Much of it, however, is good soil, but the danger of frequent overflow lessens its agricultural value, particularly on the southern side of Kaskaskia Island and just west of the mouth of Kaskaskia river.

Management.—The higher portions are becoming acid and require about 2 tons of limestone an acre to grow sweet clover or alfalfa; otherwise no fertilizer treatment is advised. It is good alfalfa land unless subject to frequent overflow.

Brown Fine Sandy Loam (1471)

Brown Fine Sandy Loam, Bottom, is similar in origin to Yellow-Brown Fine Sandy Loam (1379) but is an older formation, as is shown by the development of fairly distinct strata or horizons. A total of less than 2 square miles of the type occurs in the county.

The surface soil is about 10 inches deep and is a brown sandy loam. The subsurface extends to a depth of about 20 inches and is a grayish brown fine sandy loam. The subsoil to the depth sampled (40 inches) is a brownish gray fine sandy silt loam.

Management.—This is an excellent soil. It is not acid in the surface and is only very slightly acid in the subsurface and subsoil.

Brown-Gray Clay Loam On Tight Clay (1422.1)

Brown-Gray Clay Loam On Tight Clay occurs in relatively small areas in the Mississippi bottom south of Modoc station. The total area of the type in the county is 1.55 square miles.

The surface soil is a brown clay and is about 8 inches deep. The subsurface in places is drab clay which extends without change to 40 inches or more in depth. In other places there is a grayish drab clay stratum to a depth of about 14 inches and then a highly plastic drab clay to 40 inches or more in depth.

Management.—This type is not essentially different in management requirements from Drab Clay (1415). It is a little easier to work, but it is in need of improved drainage to make it a desirable soil for general farming.

(f) RESIDUAL SOILS

The total area of the formations in Randolph county mapped as Residual Soils comprizes only 2.32 square miles. Nearly one-half of this total area is occupied by outcrops of sandstone which have no agricultural value. The limestone outcrops may in many cases be used as local sources of ground limestone or of burned lime, if conditions are such that home burning of the stone can be practiced. Miscellaneous samples examined indicate that much of this rock is of very good quality for such a purpose. The Stony Loam (098) which comprizes less than one-half square mile is of no value other than for pasture or timber.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order intelligently to interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The type is the unit of classification and each type has definite characteristics. In establishing types, the following factors are taken into account: the character of the horizons composing the soil as to depth and thickness, physical composition, structure, organic-matter content, color, reaction, and carbonate content; the topography; the native vegetation; and the geological origin of the soil.[1]

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infiinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

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[1] Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following explanations are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of four or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

For further information regarding these geological areas the reader is referred to the general map published in Bulletin 123.

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken

by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron.* Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil conditions, which may result from poor drainage, poor physical condition, or from an actual deficiency in one or more of the elements of plant food.

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybeans seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

Table 5 shows the requirements of some of our most common field crops with respect to the seven plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and seven from the soil. Nitrogen, one of these seven elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5.

[2]Young second year's growth ready to plow under as green manure.

[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for

the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than

this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates

of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

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[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4_1 have been found satisfactory. Some commercial firms are also offering similar preparations which are satisfactory.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be

the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, acid phosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form or rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium;

so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the

Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately

furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Wheat or oats (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to those Occurring in Randolph County)

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, in included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated (aP = acid phosphate, bP = bonemeal, rP = rock phosphate, sP = slag phosphate)
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
Le = Legume used as green manure
Cv = Cover crop
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

THE SPARTA FIELD

A University soils experiment field is located in Randolph county immediately north of Sparta. This field has been in operation since 1916. It comprizes 20 acres of light-colored, loessial soils characteristic of the region. The county map indicates the presence of two soil types—Light Gray Silt Loam On Tight Clay and Yellow-Gray Silt Loam. However, with accumulating ex-

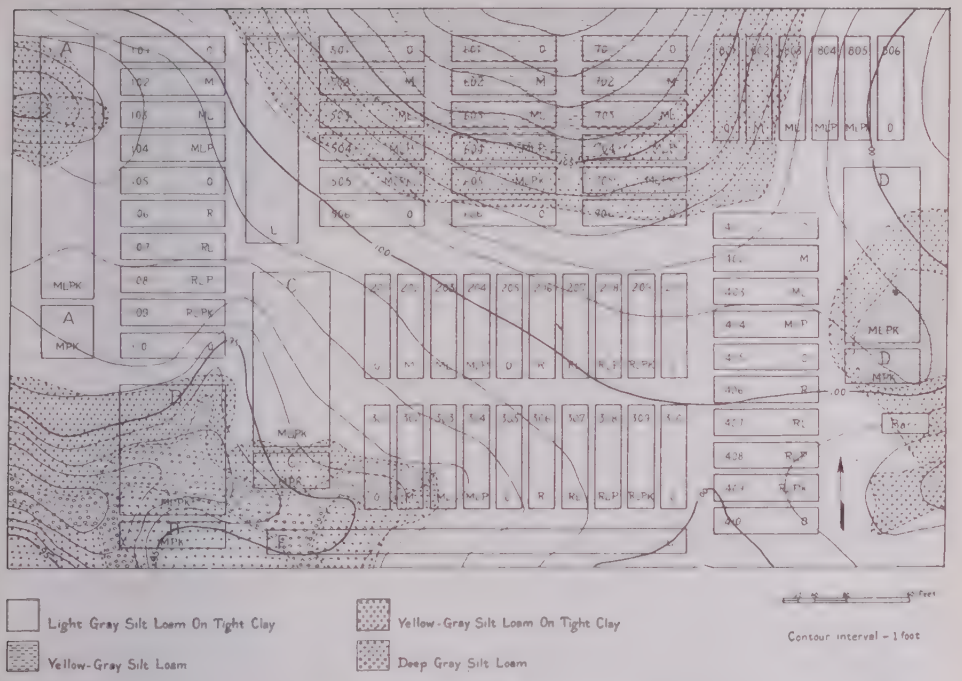
Light Gray Silt Loam On Tight Clay
Yellow-Gray Silt Loam
Yellow-Gray Silt Loam On Tight Clay
Deep Gray Silt Loam
Contour interval - 1 foot

FIG. 2.—DIAGRAM OF SPARTA FIELD

This diagram shows the five separate systems of plots maintained on this field, the soil treatments applied, the location of the different soil types, and, by means of contour lines, the natural drainage of the field.

perience in the soil survey, certain characteristics have come to attention which formerly were not recognized and which, in some instances, call for reclassification of types. Thus it happens that a closer examination of this field reveals the presence of small areas of two additional soil types—Yellow-Gray Silt Loam On Tight Clay and Deep Gray Silt Loam. The distribution of these soil types, as well as the arrangement of plots, is charted on the accompanying diagram (Fig. 2). The topography of the land is also indicated on the diagram by contour lines.

The field is laid out into five separate systems of plots, each system with its own program of crop rotation.

The 100, 200, 300, and 400 Series

The four series of plots designated as 100, 200, 300, and 400, with the exception of parts of two plots, all lie on the soil type mapped as Light Gray Silt Loam On Tight Clay. They are under a crop rotation of corn, soybeans, wheat, and clover (chiefly sweet clover). Until 1921 it was the practice to seed cowpeas as a cover crop in the corn on the residues plots. The soil treatments are as indicated in the accompanying diagram and tables, and they have been applied in the manner previously described, with the exception that the initial application of limestone was 5 tons an acre and in 1922 the periodic application of this material was discontinued until its further need should become apparent.

TABLE 7.—SPARTA FIELD: SERIES 100, 200, 300, 400

Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1916 Corn[1]	1917 Soybeans[4]	1918 Wheat[4]	1919 Soybeans[4]	1920 Corn	1921 Soybeans	1922 Wheat	1923 Sweet clover	1924 Corn	1925 Soybeans
101	0	14.8	(.99)	7.3	(.85)	8.6	5.5	11.2	0.00	2.0	(.72)
102	M	18.2	(1.05)	7.7	(.92)	13.6	5.8	8.5	0.00	.3	(.79)
103	ML	16.8	(1.33)	12.3	(1.38)	21.6	11.7	15.7	.50	17.4	(1.71)
104	MLrP	19.8	(1.36)	15.3	(1.38)	21.8	10.5	15.8	.41	17.2	(1.85)
105	0	13.8	5.8	2.7	..[5]	11.0	4.7	4.2	0.00	.3	(.65)
106	R	16.6	9.2	5.2	..[5]	13.8	6.0	4.2	0.00	.9	(.88)
107	RL	21.2	9.8	13.2	..[5]	11.4	10.8	13.7	.41	27.8	(1.51)
108	RLrP	20.0	9.5	13.0	..[5]	8.6	9.5	12.0	.22	27.8	(1.74)
109	RLrPK	18.6	11.3	16.7	..[5]	20.6	10.0	16.0	.44	32.0	(1.85)
110	0	17.4	(.99)	4.2	(.75)	9.4	5.5	3.5	0.00	1.2	(1.07)

		Soybeans[1]	Corn	Soybeans	Wheat	Clover	Corn	Soybeans	Wheat	Sweet clover	Corn
201	0	(1.37)	28.0	(.58)	2.8	(0.00)	34.2	3.5	2.7	0.00	26.8
202	M	(1.16)	31.4	(.80)	3.2	(0.00)	30.6	5.0	4.2	0.00	39.2
203	ML	(1.41)	49.4	(1.15)	20.2	(1.66)	42.0	8.3	14.0	.50	53.6
204	MLrP	(1.60)	49.4	(1.05)	20.0	(1.73)	41.8	8.3	13.8	.17	62.0
205	0	7.7	28.2	7.0	2.7	0.00	22.8	3.3	2.2	0.00	19.2
206	R	7.2	36.0	6.3	2.3	0.00	28.2	3.7	2.0	0.00	23.0
207	RL	10.3	35.0	9.7	20.0	1.50	22.4	8.3	10.0	.17	48.8
208	RLrP	8.8	39.0	11.0	22.5	1.87	22.2	8.5	11.7	.17	51.4
209	RLrPK	9.7	47.0	9.3	21.0	1.69	23.8	8.7	17.8	.33	66.0
210	0	(.96)	28.0	(.55)	2.8	(0.00)	2.8	3.2	3.7	0.00	17.0

		Wheat[2]	Soybeans[4]	Corn	Soybeans	Wheat	Sweet clover	Corn	Soybeans	Wheat	Sweet clover
301	0	6.3	(.76)	1.0	(1.12)	10.8	0.00	19.4	9.3	.8	0.00
302	M	6.7	(.85)	3.2	(1.40)	20.5	0.00	23.8	12.0	2.0	0.00
303	ML	9.0	(.70)	5.0	(2.00)	27.2	1.00	33.0	25.7	2.8	3.18
304	MLrP	8.2	(.63)	4.4	(2.02)	27.5	1.33	31.8	24.5	3.5	1.98
305	0	1.8	3.3	.4	..[5]	8.8	0.00	6.4	3.5	.3	0 00
306	R	3.7	4.7	.4	..[5]	9.7	0.00	11.2	7.3	.5	0.00
307	RL	8.8	8.8	.2	..[5]	20.8	.83	19.8	22.7	6.5	2.27
308	RLrP	9.2	9.7	.2	..[5]	22.2	.83	19.2	25.7	5.7	2.83
309	RLrPK	11.0	8.3	.2	..[5]	26.7	1.00	19.8	21.7	7.2	4.50
310	0	5.0	(.66)	.1	(.42)	5.2	0.00	8.4	5.0	.5	0.00

		Soybeans[3]	Wheat[4]	Clover[4]	Corn	Soybeans	Wheat	Sweet clover	Corn	Soybeans	Wheat
401	0	(.48)	10.5	(0.00)	5.4	(.48)	6.7	0.00	15.0	2.0	3.0
402	M	(.67)	15.0	(0.00)	4.6	(.62)	9.2	0.00	28.0	4.7	6.7
403	ML	(.73)	24.2	(1.15)	3.0	(.88)	19.0	2.83	42.8	14.3	20.7
404	MLrP	(.80)	27.2	(1.55)	4.4	(1.00)	17.8	3.00	44.2	14.8	25.7
405	0	5.2	18.8	0.00	9.0	6.7	12.5	0.00	23.0	4.5	7.8
406	R	6.3	17.2	0.00	9.8	6.2	11.2	0.00	23.8	4.5	8.3
407	RL	8.0	23.5	2.92	10.6	11.3	17.5	2.17	34.0	11.5	24.7
408	RLrP	6.0	25.3	2.75	10.2	12.8	19.2	3.00	32.4	11.8	26.5
409	RLrPK	6.5	23.5	3.67	14.6	14.8	17.2	3.00	39.2	14.8	22.2
410	0	(.61)	16.2	(0.00)	9.6	5.2	11.0	0.00	25.8	2.0	5.8

The heavier rules mark the beginning of full soil treatment.

[1]Lime and phosphorus only. [2]No residues or manure. [3]No residues, manure, or potassium. [4]No manure. [5]Harvested for seed but destroyed by continuous rain.

TABLE 8.—SPARTA FIELD, SERIES 100, 200, 300, AND 400: SUMMARY OF CROP YIELDS
Average Annual Yields—Bushels or (tons) per acre

Serial Plot No.	Soil treatment applied	Corn	Soybeans		Wheat	Clover	Sweet clover seed
			Hay	Seed			
		9 crops	*4 crops*	*4 crops*	*7 crops*	*1 crop*	*5 crops*
1	0	15.6	(.73)	5.1	5.4	(0.00)	0.00
2	M	19.4	(.90)	6.9	7.8	(0.00)	0.00
3	ML	29.8	(1.44)	15.0	17.1	(1.66)	1.60
4	MLP	30.8	(1.48)	14.5	17.7	(1.73)	1.38
			1 crop	*6 crops*			
5	0	13.4	(.65)	5.0	5.5	0.00	0.00
6	R	16.3	(.88)	5.7	5.5	0.00	0.00
7	RL	23.3	(1.51)	12.4	16.2	1.50	1.17
8	RLP	23.4	(1.74)	13.2	17.1	1.87	1.43
9	RLPK	29.2	(1.85)	13.2	18.3	1.69	1.86
			3 crops	*5 crops*			
10	0	11.4	(.68)	4.2	4.6	(0.00)	0.00

Table 7 records the yields of all crops grown on these series, and in Table 8 is a summary of the results showing the average annual yields for the different kinds of crops, including the years that the complete soil treatments have been in effect.

The low yields on the untreated plots testify to the natural poverty of this soil, altho this particular piece of land, on account of its favorable location with respect to drainage, is rather more productive than the general run of the type that it represents.

Neither manure nor residues, used alone, has much effect toward crop improvement. A sharp increase, however, follows the application of limestone used with either manure or residues. Without limestone, clover refuses to grow; with limestone, fair crops of clover have been obtained. Rock phosphate has produced no significant effect, whether used with manure or with residues.

Potassium seems to have been of some benefit to the corn but not to the

FIG. 3.—CORNER OF THE SPARTA EXPERIMENT FIELD

A field of 20 acres representative of land in the vicinity is devoted to experiments designed to find ways and means of building up the fertility of the soil.

other crops. It is questionable, however, whether the increase in corn yield would cover the cost of material as it was used in these experiments. It is possible that smaller quantities applied direct to the corn crop would prove a more economical way to use potassium fertilizer on this soil.

The 500, 600, 700, and 800 Series

The 500, 600, 700, and 800 series constitute another system of plots, under another program of cropping. The yields of all crops harvested on these plots are recorded in Table 9. These yields are not summarized, for the reason that the changes in the cropping system, together with the natural soil variations of these plots (see Fig. 2), have complicated conditions so that comparisons of averages at this time would scarcely have significance. The records of these plots, however, do contain some matters of practical interest that are worthy of attention.

The cropping program on these plots for several years included potatoes, wheat, and clover, rotating on three of the series, while alfalfa occupied the fourth series. In 1921 the rotation was changed to wheat, oats, sweet clover, and potatoes, with sweet clover seeded as a catch crop in the wheat. In 1924

TABLE 9.—SPARTA FIELD: SERIES 500, 600, 700, 800
Annual Crop Yields—Bushels or (tons) per acre

Plot No	Soil treatment applied	1916	1917	1918	1919	1920	1921	1922	1923		1924	1925
		Soybeans[1]	Potatoes	Wheat	Clover	Potatoes	Wheat	Oats	Sweet clover		Corn	Cowpea hay
501	0	(1.28)	25.5	12.8	(0.00)	30.2	17.5	1.9	0.00		25.0	(1.13)
502	M	(1.20)	35.0	17.2	(0.00)	46.2	17.7	3.8	0.00		37.2	(1.27)
503	ML	(1.28)	34.0	21.3	(1.22)	64.8	19.7	4.4	.82		52.8	(2.03)
504	MLrP	(1.22)	33.5	23.5	(1.63)	21.7	23.0	1.9	.71		38.2	(2.26)
505	MLrPK	(1.20)	23.3	23.5	(1.91)	0.0	24.3	1.3	1.14		25.4	(2.82)
506	0	(1.07)	12.2	14.3	(0.00)	0.0	21.8	.9	0.00		3.0	(1.87)
			Alfalfa[2]	Alfalfa[2]	Alfalfa[2]	Alfalfa[2]	Potatoes	Wheat	Oats	Stubble clover	Cowpea hay	Timothy-Clover hay
601	0	.....	(.49)	(1.54)	(1.03)	(1.56)	39.5	11.0	21.9	(0.00)	(1.09)	(.43)
602	M	.....	(.58)	(1.80)	(1.10)	(1.70)	43.5	11.3	27.5	(0.00)	(1.54)	(.86)
603	ML	.....	(3.23)	(4.32)	(2.18)	(3.10)	51.3	15.0	31.3	(.96)	(1.99)	(1.67)
604	MLrP	.....	(3.25)	(3.67)	(2.00)	(2.40)	41.0	18.7	32.5	(.99)	(1.74)	(1.76)
605	MLrPK	.....	(1.72)	(2.96)	(1.27)	(1.01)	26.0	12.7	26.3	(.94)	(1.45)	(1.50)
606	0	.....	(0.00)	(0.00)	(0.00)	(0.00)	5.5	4.2	6.6	(0.00)	(.41)	(.26)
		Wheat[1]	Soybeans[2]	Potatoes	Wheat	Clover	Oats	Potatoes	Wheat		Sweet clover	Wheat
701	0	5.7	(1.51)	10.3	10.3	(0.00)	19.1	30.0	8.5		(0.00)	10.8
702	M	5.3	(1.52)	13.8	10.5	(0.00)	27.5	37.8	11.7		(0.00)	15.8
703	ML	5.2	(1.89)	20.7	16.0	(1.76)	55.0	51.7	16.2		(1.80)	28.3
704	MLrP	4.0	(1.80)	16.0	18.8	(1.59)	57.5	53.0	20.8		(2.60)	38.2
705	MLrPK	3.0	(1.89)	6.7	17.8	(1.59)	53.4	43.3	21.3		(2.80)	40.8
706	0	.3	(.91)	3.3	6.3	(.43)	17.8	18.3	5.7		(.13)	9.2
		Potatoes[1]	Wheat[2]	Clover[2]	Potatoes	Wheat	Clover	Soybeans	Corn		Wheat	Corn
801	0	30.3	24.8	(.72)	20.0	10.0	(0.00)	3.3	7.6		2.8	15.0
802	M	25.5	20.5	(.72)	32.7	15.8	(0.00)	3.7	9.2		3.2	14.6
803	ML	30.5	22.0	(.95)	26.2	19.2	(1.02)	6.3	16.8		7.8	58.2
804	MLrP	17.2	27.2	(.95)	4.2	20.2	(1.18)	5.7	16.4		8.7	68.0
805	MLrPK	17.2	30.2	(1.50)	1.8	25.2	(1.13)	7.0	16.4		11.7	63.2
806	0	32.0	22.3	(0.00)	1.3	11.2	(.54)	3.3	9.6		4.0	20.6

The heavier rules mark the beginning of full soil treatment; the double rule indicates a change in the cropping system.

[1]Lime and phosphorus only. [2]No manure.

another change was made whereby a rotation of corn, cowpeas, clover-timothy mixture, and wheat with sweet clover catch crop, was adopted.

It is of interest to observe that in the four years of the test on the 600 series, very fair crops of alfalfa were produced where limestone was applied, altho it is to be noted that, with its somewhat rolling topography, this piece of land is favorably situated for alfalfa.

Another point brought out by these data is that this land is not adapted to potato growing. In the seven years' experience only poor yields were obtained even on the best treated plots.

TABLE 10.—SPARTA FIELD: PLOTS A, B, C, D

Annual Crop Yields—Bushels or (tons) per acre

Plot	Soil treatment applied	1916 Alfalfa seeding[1]	1917 Alfalfa[1]	1918 Alfalfa[1]	1919 Alfalfa[1]		1920 Alfalfa[1]		1921 Soybeans[1]		1922 Wheat	1923 Oats	1924 Corn	1925 Wheat
A	MLrPK.....	.....	(2.72)	(3.12)	(.94)		(.27)		13.7		18.9	27.6	23.8	21.2
A	MrPK.....	.....	(0.00)	(0.00)	(0.00)		(0.00)		4.0		13.2	5.3	.5	14.5
		Wheat[1]	Winter oats[1]	Sweet clover[1]	Wheat		Winter oats	Stubble clover	Sweet clover		Alfalfa	Alfalfa	Alfalfa	Corn
B	MLrPK.....	5.0	2.4	(1.50)	17.7		37.8	(1.12)	1.57		(2.89)	(3.45)	(2.61)	58.7
B	MrPK.....	5.5	2.5	(0.00)	10.3		38.8	(0.00)	.33		(1.20)	(1.62)	(1.45)	38.2
		Soy-beans[1]	Wheat	Winter oats[2]	Sweet clover		Wheat		Winter oats	Stubble clover	Sweet clover	Wheat	Alfalfa	Alfalfa
C	MLrPK.....	5.3	33.5	.....	(1.58)		24.7		53.1	(.73)	3.30	25.5	(2.97)	(3.07)
C	MrPK.....	5.7	21.3	.....	(0.00)		12.2		29.4	(0.00)	.97	9.5	(2.13)	(1.66)
		Oats[1]	Sweet clover[1]	Wheat	Winter oats	Stubble clover	Sweet clover		Wheat		Oats	Sweet clover	Wheat	Alfalfa
D	MLrPK.....	15.2	(1.21)	22.4	39.5	(1.58)	.67		23.8		6.9	.68	16.8	(2.50)
D	MrPK.....	25.0	(0.00)	18.2	36.2	(0.00)	0.00		15.5		4.7	.65	14.2	(1.72)

The heavier rules mark the beginning of full soil treatment.

[1]No manure. [2]Crop failure.

Plots A, B, C, and D

Plots A, B, C, and D are irregular in size and shape, being distributed about the field in odd spaces among the other series. Each plot is treated with manure, limestone, rock phosphate, and potassium salt. A small area, or subplot, for each plot remains without limestone. A rotation of wheat, winter oats, and sweet clover on three of the plots, with alfalfa remaining four years on the fourth plot, was followed for the first few years. In 1921 a slight change was made, spring oats being substituted for winter oats. In 1923 alfalfa was introduced on a second plot. The regular applications of limestone were discontinued in 1922.

Because of irregularities in soil type and changes in cropping, no attempt is made at this time to summarize the results from these plots. The annual yields, however, are given in detail in Table 10, as a matter of record.

FIG. 4.—SWEET CLOVER GROWING ON THE SPARTA FIELD

These two plots in the same series were seeded alike to sweet clover. The application of limestone was the principal factor in the difference in results. Without limestone sweet clover will not grow on this land.

Plots E and F

Plots E and F were laid out in 1920. They were treated with limestone at the rate of 5 tons an acre. Small grains and legumes have been grown alternately, but otherwise no definite plan of crop rotation has been followed. The plots have served mainly for variety tests rather than for any special soil investigations. For the sake of any information of interest that may be contained, the crop yields are placed on record in Table 11.

TABLE 11.—SPARTA FIELD: PLOTS E AND F
Annual Crop Yields—Bushels or (tons) per acre

Plot	Soil treatment applied	1920	1921	1922	1923	1924	1925
E	Limestone.....	Oat hay (.17)	Sweet clover .63	Soybeans 8.0	Wheat 17.8	Sweet clover 2.75	Wheat 17.3
F	Limestone.....	Winter barley 18.1	Sweet clover .67	Wheat 14.5	Sweet clover .64	Wheat 12.0	Oats 19.3

THE ODIN FIELD

An experiment field was established at Odin in Marion county in 1902. The field is located mainly on Gray Silt Loam On Tight Clay. A detailed examination, however, shows the presence of Gray Silt Loam On Compact Red Clay in the northwest corner of the field. There is also a very small patch of Yellow-Gray Silt Loam located on the border, so that it should not materially affect the plots proper.

A part of the field is tile-drained, but owing to the impervious nature of the subsoil satisfactory results have not been obtained from the tiling.

The field is laid off into different systems of plots as described below.

Series 100, 200, 300, and 400

The rotation chiefly practiced on Series 100, 200, 300, and 400 has been corn, legumes (cowpeas or soybeans), wheat, and clover. Until 1922 the clover was alsike, soybeans being substituted if the clover failed. Since that time sweet clover has been used instead of alsike. A part of the time cowpeas were seeded in the corn, at the last cultivation. The first five plots in each series were not tile-drained, while the last five plots were tile-drained.

Phosphorus was applied in the form of steamed bone meal, used at the rate of 200 pounds an acre a year until 1923, when the total application of the bone meal was evened up on all plots to 4,800 pounds an acre and temporarily discontinued. Potassium was applied at the annual rate of 100 pounds an acre of potassium sulfate until 1923. At that time the total application was evened up to 2,500 pounds on each of the potassium plots, and plans made to continue the application on the southwest halves of the plots at the normal rate.

In 1902 slaked lime at the acre rate of 475 pounds was applied to the limed plots, and in 1903 an additional 2 tons was applied to these plots. No more lime was added until 1908, after which it was applied regularly at the annual rate of 500 pounds of limestone an acre to the northwest halves and 1,000 pounds an acre to the southeast halves of these plots. In 1922 these applications were temporarily discontinued until further need for lime appears.

Crop residues and cover crops have been regularly plowed down on the residue plots. The return of the wheat straw was discontinued in 1922. From 1907 to 1919 the northeast half of each plot was subsoiled at the time of plowing for corn.

Table 12 summarizes the yields, by crops, for the period during which the plots have been under their full fertilizer treatment. The lower section of the table gives a more condensed summary in terms of crop increases, indicating the effects of the different fertilizing materials as they were used in these experiments. These figures are based upon the results of the corresponding tiled and untiled plots averaged together.

Organic manure is provided in these experiments by plowing under crop residues and legume crops used as green manure. The crop yields show little effect from residues alone. Residues with limestone, however, have produced, with a single exception, notable increases in yields. It is of interest to note that the one crop which does not show a benefit from limestone is cowpeas, and the cowpea is generally known as a plant tolerant to soil acidity.

Regarding the phosphorus treatment on these series it will be observed that wheat shows a very marked benefit from bone meal, but the other crops have responded indifferently. With a single exception, the potassium treatment has been attended by some increase in yield, and in the case of the corn this increase is very pronounced.

These results on the whole point to the necessity of using limestone in connection with organic manures in improving this soil. On the farm, all available stable manure should be utilized.

TABLE 12.—ODIN FIELD: AVERAGE ANNUAL CROP YIELDS, 1903-1925
Bushels or (tons) per acre

Serial Plot No.	Soil treatment applied[1]	Corn *22 crops*	Soybeans *19 crops*	Wheat *23 crops*	Alsike clover Hay *2 crops*	Alsike clover Seed *1 crop*	Sweet clover *3 crops*	Stubble clover *2 crops*	Cowpeas Hay *8 crops*	Cowpeas Seed *1 crop*
1	0	22.8	8.1	9.5	(.11)	.42	0.00	(0.00)	(.58)	1.7
2	R	23.5	9.3	9.3	(.14)	1.25	.06	(0.00)	(.62)	2.9
3	RL	27.1	10.9	17.5	(.99)	1.67	1.71	(.70)	(.57)	2.5
4	RLP	27.1	10.3	22.5	(1.10)	1.67	1.10	(.70)	(.64)	2.3
5	RLPK	43.7	13.3	25.8	(1.87)	1.83	1.76	(.90)	(1.11)	4.6
6	0	17.7	6.4	7.2	(.19)	.92	0.00	(0.00)	(.52)	1.4
7	R	22.0	7.7	10.6	(.18)	1.50	.08	(0.00)	(.62)	2.3
8	RL	27.5	10.8	17.6	(1.07)	3.08	.99	(.41)	(.61)	2.7
9	RLP	29.0	10.6	23.8	(1.12)	2.83	.76	(.48)	(.71)	1.8
10	RLPK	40.5	13.0	25.6	(1.65)	2.00	1.37	(.78)	(1.11)	3.9
	R over 0	2.5	1.3	1.6	(.01)	.71	.07	(0.00)	(.07)	.1
	RL over R	4.6	2.4	7.6	(.87)	1.00	1.28	(.56)	(−.03)	0.0
	RLP over RL	.8	−.4	5.6	(.08)	−.13	−.42	(.04)	(.09)	−.6
	RLPK over RLP	14.1	2.7	2.7	(.65)	−.34	.59	(.25)	(.44)	2.3

[1]Plots 1 to 5 not tiled; Plots 6 to 10 tiled.

Comparative Phosphate Tests

Series 500, 600, 700, and 800 were originally plotted as one series of six long plots for the purpose of studying the relative value of various carriers of phosphorus used in equal money values on limed and unlimed land.

A rotation of corn, oats, and three years of clover-timothy meadow was first established on this series. Cowpeas were seeded in the corn for use as residues. The phosphates were applied at the annual acre rate of 200 pounds of steamed bone meal, 333 pounds of acid phosphate, 666 pounds of rock phosphate, and 250 pounds of slag phosphate. At that time these amounts were of equivalent money value. The first application of lime was at the acre rate of 1½ tons to the southeast halves. Subsequent applications were at the annual acre rate of 1,000 pounds. Potassium at the annual acre rate of 100 pounds of potassium sulfate was applied to all plots. These applications were discontinued in 1913.

The results on these plots are summarized by crops in Table 13. The lower part of the table shows differences in crop yields presumed to have resulted from applying the various forms of phosphatic fertilizers for all the crops harvested from 1904 up to 1921, after which time the plots were modified.

Altho it is recognized that these data are too meagre for final conclusions, the following comments based upon these figures for crop increases may be made. It appears that the various phosphorus carriers—bone meal, acid phosphate, rock phosphate, and slag phosphate—rank differently in efficiency, according

TABLE 13.—ODIN FIELD: COMPARATIVE PHOSPHATE TESTS
Summary of Crop Yields 1904-1921—Bushels or (tons) per acre

Plot No.	Soil treatment applied	Corn *4 crops*	Oats *3 crops*	Hay *10 crops*
501W	RKbP	23.6	43.4	(1.05)
501E	RLKbP	26.0	40.3	(1.42)
502W	RK	20.8	35.6	(.62)
502E	RKL	21.1	35.8	(1.28)
503W	RKaP	22.5	43.8	(.68)
503E	RKLaP	23.7	34.5	(1.33)
504W	RKrP	20.3	43.4	(.68)
504E	RKLrP	25.5	39.6	(1.36)
505W	RK	16.3	32.0	(.52)
505E	RKL	21.8	39.0	(1.24)
506W	RKsP	20.5	41.9	(.78)
506E	RKLsP	25.2	47.4	(1.34)
	RKbP over RK	5.1	9.6	(.48)
	RKLbP over RKL	4.5	2.9	(.16)
	RKaP over RK	4.0	10.0	(.11)
	RKLaP over RKL	2.2	−2.9	(.07)
	RKrP over RK	1.8	9.6	(.11)
	RKLrP over RKL	4.0	2.2	(.10)
	RKsP over RK	2.0	8.1	(.21)
	RKLsP over RKL	3.7	10.0	(.08)

to the kind of crop produced. Considering first the results without limestone, we find the following order of efficiency: for corn—bone, acid, slag, rock; for oats—acid, either bone or rock, slag; and for hay—bone, slag, either acid or rock. Used with limestone, the relative efficiencies run as follows: for corn—bone, rock, slag, acid; for oats—slag, bone, rock, acid; and for hay—bone, rock, slag, acid. In general, the differences are small and a careful analysis of the data shows that most of them are to be considered insignificant, that is to say, well within the experimental error.

These results illustrate well the difficulty of laying down definite rules for practice in applying phosphorus fertilizer. To this point in the discussion there has been taken into account only the effect on production. When the economy from a financial standpoint is considered, the matter becomes even more complicated, for all depends upon relative cost of materials applied as well as upon the market value of produce sold, both of which are constantly fluctuating. However, with the data of Table 13, one may compute for himself the relative economy of producing these crop increases by applying any set of prices for crops and fertilizers which appear to be most applicable according to prevailing market conditions. In so doing, however, it should be constantly borne in mind that the order of efficiency might be easily shifted thru a relatively small change in commodity prices.

In 1922 these series were replotted and a different system of rotation established for further investigation of the various forms of phosphorus fertilizer. This later work, however, has not been under way long enough to warrant summarizing at this time.

In addition to the above described series, seven plots on the Odin field have been devoted to two special rotations featuring sweet clover. On three plots a rotation of corn, cowpeas or soybeans, and wheat has been practiced. Sweet clover has been seeded in both the corn and the wheat and plowed down as a green manure for the succeeding crop. On the other four plots the rotation has been corn, cowpeas or soybeans, wheat, and sweet clover. In this system the sweet clover has been allowed to make its second year's growth and produce a seed crop, the straw and chaff being returned to the land. Limestone and bone meal have been used in both these rotations.

The average annual crop yields of the two systems are compared in Table 14.

TABLE 14.—ODIN FIELD: USE OF SWEET CLOVER IN ROTATIONS

Average Annual Crop Yields—Bushels per acre

Rotation	Corn *19 crops*	Soybeans[1] *15 crops*	Wheat *19 crops*	Clover seed *18 crops*
Three-year	29.3	6.2	17.1	.....
Four-year	35.8	9.2	22.2	1.56

[1]Or cowpeas.

The markedly higher production in all crops in the four-year rotation indicates the advantage of this system, in which one field out of four is devoted to the production of sweet clover, over the three-year system in which only catch crops of sweet clover are grown.

THE DUBOIS FIELD

Another experiment field on Gray Silt Loam On Tight Clay is located at DuBois in Washington county. This land lies practically level and appears to be uniform in soil type. The experiments were started in 1902. The field was laid off into a single series of plots having two sections, one tiled and the other untiled.

The rotation practiced the first eight years was corn, oats, and wheat followed by a legume. After two of these rotations the order was changed to corn, oats, clover, wheat, with a seeding of sweet clover and alsike on the residues plots for use as a green manure. Since there appeared to be little difference between the tiled and untiled sections, another change in cropping was made in 1922 by which corn is grown on one section and wheat with a seeding of sweet clover on the other.

Five tons of hydrated lime was applied in 1902, and no further application of lime was made until 1922, when 2 tons of limestone an acre was applied on the east section and 1,000 pounds an acre on the west section.

Until 1905 nitrogen was applied annually in approximately 650 pounds of dried blood an acre on what are now the residues plots; thereafter crop residues were substituted. Phosphorus was supplied in form of steamed bone meal applied at the rate of 200 pounds an acre a year, and potassium in 100 pounds of potassium sulfate an acre a year. In 1922 the applications of both phosphorus and potassium were discontinued temporarily.

A general summary of the annual crop yields is assembled in Table 15, and for convenience in studying the effect of the treatments the various possible comparisons are brought together in Table 16, where the results of the corresponding plots of the two sections are averaged and expressed in terms of crop increases. Some points of interest brought out by these comparisons are as follows:

Altho lime, as used in these experiments, has produced some increase in all crops, when applied alone it does not raise the plane of production sufficiently to give a profitable system of farming. In the presence of other fertilizing materials, however, its effectiveness is greatly enhanced.

The response to residues in the various combinations is rather complex. In some cases the increases to be ascribed to residues are marked. In the treatment with lime, phosphorus, and potassium, the effect of residues on the grain crops is quite indifferent, while on the hay crop it is very pronounced. In considering these residues results it should be noted that they include the data of the earlier years, when dried blood was used instead of crop residues to furnish nitrogen.

Phosphorus has given increases in all combinations in all crops, but the most significant effect produced was on the wheat. Potassium has produced a remarkable effect on the corn; in some cases the yields have been practically doubled following the potassium treatment. These results in general confirm those of the Odin field located on the same soil type, in that wheat responds in a notable way to phosphorus treatment while corn receives its greatest benefit from potassium treatment. A rational system of general farming designed to

TABLE 15.—DUBOIS FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1902-1923—Bushels or (tons) per acre

Plot No.[1]	Soil treatment applied[2]	Wheat *6 crops*	Corn *6 crops*	Oats *5 crops*	Clover Hay[3] *4 crops*	Clover Seed *2 crops*	Soybeans *1 crop*
1	0	5.4	10.8	14.0	(.58)	.....	3.5
2	L	9.7	13.0	23.0	(.61)	.....	6.7
3	LR	13.6	17.6	30.8	(.89)[3]	.80	7.2
4	LP	20.7	17.1	35.2	(1.04)	.....	8.5
5	LK	16.7	25.9	30.8	(.89)	.....	9.3
6	LRP	26.5	17.5	33.8	(1.17)[3]	1.88	8.2
7	LRK	19.7	25.2	32.9	(1.74)[3]	2.38	7.8
8	LPK	28.0	29.1	37.6	(1.67)	.....	9.5
9	LRPK	27.0	28.8	34.8	(2.22)[3]	2.09	7.8
10	RPK	18.9	22.1	26.5	(2.00)[3]	2.09	6.3
11	0	6.3	11.7	14.3	(.54)	.....	3.3
12	L	13.6	13.8	22.5	(.77)	.....	6.2
13	LR	16.2	16.4	28.0	(1.33)[3]	1.33	6.7
14	LP	22.2	13.3	32.4	(1.14)	.....	7.2
15	LK	16.1	25.2	33.8	(1.23)	.....	7.8
16	LRP	27.0	18.3	38.1	(2.11)[3]	2.42	8.8
17	LRK	23.3	29.7	32.4	(2.19)[3]	2.04	10.2
18	LPK	30.0	32.4	34.8	(1.88)	.....	10.3
19	LRPK	28.0	30.8	33.1	(2.67)[3]	2.08	11.3
20	RPK	18.8	21.8	30.2	(2.41)[3]	2.25	6.7

[1]Plots 1 to 10 not tiled. Plots 11 to 20 tiled.
[2]Until 1905 dried blood was applied instead of residues.
[3]Only two crops of hay on Plots 3, 5, 7, 9, 10, 13, 16, 17, 19, and 20.

TABLE 16.—DUBOIS FIELD: EFFECT OF TREATMENT IN TERMS OF ANNUAL CROP INCREASES

Bushels or (tons) per acre

Comparison of treatments	Wheat *6 crops*	Corn *6 crops*	Oats *5 crops*	Clover hay[1] *2 or 4 crops*	Soybeans *1 crop*
Lime					
L over 0	5.8	2.2	8.6	(.13)	3.1
LRPK over RPK	8.7	7.9	5.6	(.24)	3.1
Residues					
LR over L	3.3	3.6	6.7	(.42)	.5
LRP over LP	5.3	2.7	2.2	(.55)	.7
LRK over LK	5.1	1.9	.4	(.91)	.5
LRPK over LPK	−1.5	−1.0	−2.3	(.67)	−.4
Phosphorus					
LP over L	9.8	1.8	11.1	(.40)	1.4
LRP over LR	11.9	.9	6.6	(.53)	1.6
LPK over LK	12.6	5.2	3.9	(.72)	1.4
LRPK over LRK	6.0	2.4	1.3	(.48)	.6
Potassium					
LK over L	4.8	12.2	9.6	(.37)	2.1
LRK over LR	6.6	10.5	3.3	(.86)	2.1
LPK over LP	7.6	15.6	2.4	(.69)	2.1
LRPK over LRP	.8	11.9	−2.0	(.81)	1.1

[1]Omitting any consideration of clover seed produced on certain plots.

bring this land into the highest production of which it is capable calls for the application of both these elements of plant food to be used in conjunction with limestone and organic manures.

The marked benefit to wheat and the indifferent response of all other crops following the use of bone meal suggest that in practice perhaps phosphorus could be supplied more economically by using somewhat smaller quantities of phosphatic fertilizer and applying it directly to the wheat crop. Likewise, it seems probable, judging from the relative crop responses to potassium treatment, that the expense of potassium fertilizer might be reduced by cutting down the quantity used in these tests, applying the material direct to the corn crop. The organic manures are well furnished by crop residues and legumes plowed down but, under some circumstances, at least a part of the legumes and crop residues will be utilized advantageously by pasturing or feeding them to livestock, the manure produced therefrom to be carefully conserved and regularly returned to the land.

THE ALHAMBRA FIELD

As representing field experiments on Brown-Gray Silt Loam On Tight Clay, the results of the Alhambra experiment field are presented. This field, located in Madison county near Alhambra, was established in 1918. It is devoted primarily to crop investigations, but the work on certain plots is so planned as to show the effect of soil treatment.

The land is flat and portions of it are practically level. On half of the field tile drainage has been provided, but owing to the impervious nature of the subsoil the effect has not been satisfactory. A crop rotation of corn, oats, mammoth clover, and wheat seeded with sweet clover for green manure, has been practiced. The land is managed as under the grain system of farming, no animal manure being employed. All plots except certain checks receive limestone and rock phosphate in addition to the residues treatment.

The effects of the soil treatments are presented in Table 17, which gives a summary of the annual crop yields obtained during the time the plots have been under their complete treatments.

So far as crop yields indicate, there is little evidence to show the advantage of tiling. Excepting the clover, all crops appear to have received some benefit from the combination of limestone and rock phosphate. However, under present market conditions the gains would scarcely be sufficient to return a financial profit. The response to rock phosphate without limestone is irregular. The wheat shows an increase in both tiled and untiled sections, but the corn and oats

TABLE 17.—ALHAMBRA FIELD: SUMMARY OF CROP YIELDS

Average annual yields 1919-1924—Bushels or (tons) per acre

Soil treatment	Wheat *5 crops*		Corn *5 crops*		Oats *4 crops*		Clover *1 crop*		Soybeans *3 crops*	
	Tiled	Untiled	Tiled	Untiled	Tiled	Untiled	Tiled	Untiled	Tiled	Untiled
R	20.4	19.2	19.9	20.2	19.4	19.3	.53	.72	19.7	20.0
RP	23.1	22.6	24.2	18.5	24.1	17.9	.58	.59	18.4	19.2
RLP	23.1	24.3	32.3	26.3	25.5	25.4	.50	.63	21.7	22.5

show increases on the tiled plots only. There is no test of limestone without phosphate on this field.

THE PANA FIELD—SERIES 400 AND 500

The Pana field, located at Pana in Christian county, lies partly on the soil type Brown-Gray Silt Loam On Tight Clay. With the exception of two small spots all plots on Series 400 and 500, situated on the east end of the field, are located on this type.

The Pana field was laid out in 1912. During the first ten years the 400 and 500 series were parts of a five-series system under a rotation of corn, oats, clover, wheat, and alfalfa. In 1922 two independent rotations were established by which the 400 and 500 series were combined with the 300 series and brought under a three-year rotation of corn, oats, and wheat. The several crops produced, together with the plot treatments, are shown in Table 18. The average annual yields are given in this table, and the various possible comparisons of soil treatments are brought together in Table 19, where the results are expressed in terms of crop increase. The following observations may be made, making full allowance for a rather large experimental error due to the small numbers of crops represented.

Manure, used alone, has had little effect aside from that on the wheat, where an increase of nearly 5 bushels is shown. Residues, alone, have given practically the same increase in wheat as has manure and they have likewise improved the corn yields.

Limestone is the outstanding treatment on this field. With few exceptions, all crops show a decided improvement following the use of limestone, and many of the crop increases are very pronounced. The alfalfa especially was greatly benefited by it.

Phosphorus, applied in the form of rock phosphate, proved consistently beneficial to the wheat crop but, in general, other crops have not responded in a profitable manner to this treatment.

Potassium, applied in the form of kainit, appears in these experiments in but a single combination. In most of the crops the differences are not significant. In fact, several of the figures carry the minus sign, so that upon the basis of these experiments the conclusion is that potassium is not needed on this soil.

By the term "cover crop," as used in these experiments, is meant the practice of seeding a legume catch crop in the wheat, and in some instances in the corn, to be plowed down in preparation for the crop that follows. Cover crops in the three combinations tested give conflicting results. Used with manure alone, the increases in crop yield are considerable, but with limestone in addition to manure these gains are greatly reduced.

The results on the whole support the recommendation that limestone and organic manures be used for building up this land. If wheat is grown, phosphorus fertilization is likely to be profitable; otherwise a financial return sufficient to cover expenditure appears to be doubtful.

TABLE 18.—PANA FIELD, SERIES 400 AND 500: SUMMARY OF CROP YIELDS, 1914-1922

Bushels or (tons) per acre

Plot No.	Soil treatment	Corn *4 crops*	Oats *3 crops*	Wheat *3 crops*	Alfalfa *3 crops*	Clover *1 crop*	Soybeans[1] *2 crops*
401	0	22.1	34.6	13.4	(.95)	(1.01)	9.7
402	M	20.3	41.8	17.9	(1.04)	(1.40)	9.5
403	ML	27.6	52.1	27.7	(3.19)	(2.44)	12.5
404	MLP	32.3	49.3	29.9	(3.36)	(2.38)	12.3
405	0	19.7	43.5	13.4	(1.28)	1.58	10.3
406	R	27.5	40.7	17.8	(1.39)	2.25	9.6
407	RL	34.4	53.1	29.6	(3.09)	2.42	15.3
408	RLP	37.2	56.2	35.9	(3.65)	2.08	12.3
409	RLPK	32.3	57.6	31.8	(3.76)	2.00	14.0
410	0	27.6	49.5	14.4	(1.59)	(2.27)	12.7
411	CvM	30.0	58.0	19.0	(1.66)	(2.21)	13.7
412	CvML	32.2	49.7	26.5	(3.19)	(2.66)	17.0
413	CvMLP	35.4	54.5	29.9	(3.10)	(2.51)	13.3
414	CvMP	27.2	52.3	24.4	(.89)	(2.14)	11.3
415	0	20.8	42.3	12.6	(.56)	(1.82)	9.6
416	0	19.4	39.3	11.6	(.64)	(1.54)	9.0

[1]On manure plots one crop was harvested as hay but evaluated as seed in this average.

TABLE 19.—PANA FIELD, SERIES 400 AND 500: EFFECT OF TREATMENTS IN TERMS OF ANNUAL CROP INCREASES

Bushels or (tons) per acre

Comparison of treatments	Corn *4 crops*	Oats *3 crops*	Wheat *3 crops*	Alfalfa *3 crops*	Clover *1 crop*	Soybeans *2 crops*
Manure						
M over 0	1.6	0.0	4.8	(.04)	−.24	−.8
Residues						
R over 0	5.6	−1.1	4.7	(.39)	....	−.7
Limestone						
L over M	7.3	10.3	9.8	(2.15)	(1.04)	3.0
L over R	6.9	12.4	11.8	(1.70)	.17	5.7
LCvM over CvM	2.2	−8.3	7.5	(1.53)	(.45)	3.3
LCvMP over CvMP	8.2	2.2	5.5	(2.21)	(.37)	2.0
Phosphorus						
PML over ML	4.7	−2.8	2.2	(.17)	(−.06)	−.2
PCvML over CvML	3.2	4.8	3.4	(−.09)	(−.15)	−3.7
PCvM over CvM	−2.8	−5.7	5.4	(−.77)	(−.07)	−2.4
PRL over RL	2.8	3.1	6.3	(.56)	−.34	−3.0
Potassium						
RLPK over RLP	−4.9	1.4	−4.1	(.11)	−.08	1.7
Cover Crop						
CvM over M	9.7	16.2	1.1	(.62)	(.81)	4.2
CvML over ML	4.6	−2.4	−1.2	(0.00)	(.22)	4.5
CvMLP over MLP	3.1	5.2	0.0	(−.26)	(.13)	1.0

THE ELIZABETHTOWN FIELD

The Elizabethtown experiment field was established by the University in 1917, in the unglaciated hilly section of southern Illinois. This field is located in Hardin county about two miles north of Elizabethtown. The soil is of loessial formation, the predominating type on this field being classified as Yellow Silt

Loam. A detailed examination, however, shows the presence of some Yellow-Gray Silt Loam and also a very small patch of Stony Loam. The land is extremely rough in topography, the contour map showing a range in elevation of 42 feet on that part of the field occupied by the present plots. Erosion, therefore, is a serious problem. The field embraces about 32 acres, of which area about one-half is laid off into plots. There are four series of 10 fifth-acre plots each, included in a major rotation. Another series of 10 tenth-acre plots is devoted to another rotation, and in addition to these there are three other plots designated as A, B, and C, upon which a special phosphate test is being carried on.

The major rotation formerly included corn (with rye cover crop), soybeans, wheat, and sweet clover, but this was changed in 1923 to a rotation of corn, wheat, clover-timothy mixture, and wheat with sweet clover seeding on the residue plots. The plot treatments are indicated in the following table of results. The difficulty of obtaining satisfactory experimental data on land of such rough topography is obvious. There are, however, certain effects standing out in such bold relief as to leave no doubt as to their significance. The results for the different crops are summarized in Table 20, showing the yields since full treatment has been in force.

These results show extremely poor yields on the untreated land, with no improvement from the use of manure alone or residues alone. A sharp increase in yield, however, follows the application of limestone along with either manure or residues. Rock phosphate seems to have produced a beneficial effect on the corn, on the wheat following legumes, and on the timothy-clover mixture, in both the manure and the residues systems. The potassium treatment as applied in these experiments does not show sufficient benefit to cover the cost. The following general observations are of interest. The wheat following legumes has a much more favorable place in the rotation than the wheat following corn, which fact is manifested by the relative yields. Soybeans have not proved a very successful crop on this field. It is of interest to note that the residues system appears to be fully as effective in building up this soil as the manure system, but a rational system of farming might well include livestock, in which the manure as well as all available crop residues would be utilized for soil improvement.

TABLE 20.—ELIZABETHTOWN FIELD: SUMMARY OF CROPS GROWN

Average Annual Yields 1919-1924—Bushels or (tons) per acre

Soil treatment	Corn *6 crops*	Wheat following legumes *4 crops*	Wheat following corn *2 crops*	Timothy clover mixture *2 crops*	Soybeans *3 crops*	Sweet clover seed *2 crops*
0	21.4	6.9	5.0	(0.00)	2.7	0.00
M	20.4	6.5	4.4	(0.00)	3.1	0.00
ML	33.5	11.1	10.2	(.90)	4.2	2.59
MLP	38.8	15.4	9.0	(1.45)	5.2	2.42
0	14.5	6.9	2.4	(0.00)	2.3	0.00
R	15.7	6.1	2.9	(0.00)	2.5	0.00
RL	31.8	11.6	4.9	(1.02)	4.3	1.99
RLP	41.3	15.7	5.2	(1.20)	5.0	1.74
RLPK	40.7	16.6	4.9	(1.44)	4.6	1.49
0	22.5	7.3	4.4	(0.00)	3.0	0.00

The results from the minor rotation on Series 500 are too few to warrant consideration at this time.

On Plots A, B, and C a comparison of the two carriers of phosphorus, acid phosphate and rock phosphate, is under way. The acid phosphate is applied at the rate of 200 pounds an acre a year and the rock phosphate in double this quantity.

In a rotation of corn, cowpeas, and wheat, four crops of corn, three of cowpeas, and three of wheat can be compared at this time. It is of interest to note the results that thus far have been obtained, bearing in mind that the data are not sufficient to warrant drawing final conclusions as to which carrier of phosphorus will prove to be the more economical to use. Table 21 presents the crop yields from these comparative phosphate tests covering the period since the full soil treatment has been appiled.

TABLE 21.—ELIZABETHTOWN FIELD: COMPARATIVE TEST OF ACID PHOSPHATE AND ROCK PHOSPHATE

Annual Acre Yields of Crops Grown, 1921-1924—Bushels per acre

Year	Corn		Wheat		Cowpeas	
	Acid phosphate	Rock phosphate	Acid phosphate	Rock phosphate	Acid phosphate	Rock phosphate
1921.....	28.8	28.6	.....	.....	9.2	7.8
1922.....	34.4	32.0	3.2	9.8	12.5	4.7
1923.....	32.2	46.8	18.6	14.3	10.5	9.2
1924.....	54.6	59.2	13.3	8.8	.....	.....
Average...	37.5	41.7	11.7	11.0	10.7	7.2

On the whole, the differences shown in the averages are relatively small, so that it may be said that after four years the data furnish no reliable indication as to which form of phosphate is the more effective on this field in increasing crop yields.

THE OLD VIENNA FIELD

From 1902 to 1911 the University conducted an experiment field in Johnson county, about two miles southeast of Vienna, on land that was described at the time as "red clay, a soil typical of the hill sections of the state." The soil is characteristic of much of the type designated as Yellow Silt Loam. The field comprized a tract of 5.6 acres of land rolling in topography, a portion of which was low and wet. It was not tile-drained.

Previous to 1902 this land had been cultivated for about fifty years, after which it was said to be still capable of producing fair crops of corn and wheat.

For the experiment work the field was laid out into three series of plots one-fifth acre in size, each series containing 5 plots. A crop rotation of wheat, corn, and cowpeas was started; but in 1905 this rotation was changed to corn, oats, wheat, and legumes. Cowpeas for plowing down were seeded in the corn at the last cultivation excepting on Plot 1. As the carrier of phosphorus, steamed bone meal was used at the rate of 200 pounds an acre a year. Potassium was applied in the form of potassium sulfate, this material being used at the annual acre rate of 100 pounds. Lime was applied in 1902 in the form of slaked lime at the rate of 1,800 pounds, and the following year limestone was added at the rate of 8 tons an acre.

Table 22 presents a summary giving the average annual acre yields of the 9 corn crops and 8 wheat crops harvested after the plots had received their respective treatments.

The great need of this land for organic matter and nitrogen is brought out in these results. Organic matter and nitrogen are furnished by the legumes in these experiments; but in order to produce a thrifty growth of legumes, it was

TABLE 22.—OLD VIENNA FIELD: SUMMARY OF THE GRAIN CROPS
Average Annual Yields 1903-1911—Bushels per acre

Soil treatment	Corn *9 crops*	Wheat *8 crops*
0	29.0	3.0
Le	29.8	5.7
LeL	39.7	10.9
LeLP	37.5	13.6
LeLPK	40.7	15.6

necessary to apply lime. Thus, upon the addition of limestone, the corn yield was increased by one-third, while the wheat yield was practically doubled. In the case of the corn, little or no effect was produced by the addition of either phosphorus or potassium treatment. In the wheat, however, an increase of about 3 bushels an acre a year appears upon the addition of phosphorus, and a further increase of 2 bushels an acre a year upon including potassium in the treatment.

The yields from the three clover crops are not summarized here but it may be stated that some very fair yields of clover were obtained on the better treated plots.

Altho these results furnish an indication of the most important needs of this land, it cannot be said that the experiments as conducted represent directly an economical system of farming. Considering the several years in which the land was given over to the growth of a green manure crop when nothing was harvested, even the yields from the best plots would scarcely be sufficient to cover the cost of maintenance. However, it appears possible that by modifying the cropping plan in some manner, as for example, substituting sweet clover for cowpeas and giving large place in the farming system to hay and pasture crops, production might be substantially increased and thus a system of farming instituted that would represent a profitable enterprise.

THE NEW VIENNA FIELD

From 1906 to 1924 another experiment field, designated as the new Vienna field, was maintained. This field was located about a mile southeast of Vienna and about a half-mile west of the old Vienna field described above. It embraced 16 acres of the badly eroded, hilly land characteristic of the region.

The soil of this field is, in general, of loessial formation. It is strongly acid in reaction. Altho the soil type appears on the county map as Yellow Silt Loam, a detailed examination of the area occupied by the field discloses on a larger-scale map three separable types, namely, Yellow Silt Loam, Yellow-Gray Silt Loam, and Deep Gray Silt Loam.

The work on this field from 1906 to 1915 was concerned with an investigation of methods of reclaiming this land primarily thru means of reducing erosion. Before taking over the field, the land, with the exception of about three acres, had been abandoned because so much of the surface soil had been washed away, and gulleying had become so bad that further cultivation was unprofitable. Some of the gulleys were four or five feet deep, so that the first step in reclaiming the land was to fill them and thus make the slopes more uniform.

The field was divided into five sections. The sections designated as A, B, and C were divided into 4 plots each, and D into 3 plots. On Section A, which included the steepest part of the area and contained many gullies, the land was built up into terraces at vertical intervals of five feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

On Section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges sufficiently high so that if the water breaks over, it will run over in a broad sheet rather than in rills thru narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about eight loads of manure an acre were turned under each year for the corn crop.

The land on Section D was washed to about the same extent as that of Section C. As a check on the different methods of reducing erosion, the land on Section D was farmed in the most convenient way, without any special effort being made to prevent washing.

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

Sections A, B, C, and D were not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section excepting D which had but three plots.

Table 23 contains a summarized statement of the results obtained. For a more detailed account of this work the reader is referred to Bulletin 207 of this Station entitled "Washing of Soils and Methods of Prevention."

These results indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected sections (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels for Section D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 5 and 6 will serve to indicate the possibility of improving this type of soil.

FIG. 5. VIEW OF AN UNIMPROVED HILLSIDE OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 6.

TABLE 23. NEW VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

FIG. 6.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD. THIS LAND FORMERLY HAD BEEN BADLY ERODED. COMPARE WITH FIG. 5.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 33

SALINE COUNTY SOILS

By R. S. SMITH, E. A. NORTON, E. E. DeTURK, F. C. BAUER, and L. H. SMITH

URBANA, ILLINOIS, JUNE, 1926

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Saline county was conducted, and Mr. H. C. Wheeler, who as leader of the field party, was in direct charge of the mapping.

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SALINE COUNTY SOILS

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SALINE COUNTY SOILS

By R. S. SMITH, E. A. NORTON, E. E. DeTURK, F. C. BAUER and L. H. SMITH[1]

LOCATION AND CLIMATE OF SALINE COUNTY

Saline county is located in the southeastern part of Illinois, 18 miles west of the junction of the Wabash and Ohio rivers. The county is rectangular in shape, 21 miles long and 18 miles wide, comprizing an area of 386 square miles. With the exception of a belt of high, rough land in the south portion, the county lies within the lower extremity of the glaciated region of the state.

The climate of Saline county is characterized by a wide range between the extremes of winter and summer, and by an abundant, well-distributed rainfall. The greatest range of temperature in any year from 1899 to 1923 was 128 degrees in 1918. The lowest temperature recorded during the entire period was —22° in 1899; the highest, 110° in 1918. The average date of the last killing frost in spring is April 14; the earliest in fall, October 24. The length of the growing season, therefore, is about 193 days.

The average annual precipitation in the county for the 24-year period from 1899 to 1923 was 44.67 inches. The average annual rainfall by months for this period was as follows: January, 4.15 inches; February, 2.79; March, 4.38; April, 4.11; May, 4.15; June, 3.51; July, 3.84; August, 4.66; September, 3.33; October, 2.90; November, 3.14; December, 3.71. The proportion of rainfall occurring during each season was: winter, 23.8 percent; spring, 28.2 percent; summer, 27.1 percent; autumn, 20.9 percent.

AGRICULTURAL PRODUCTION

Agriculture and mining are the two important industries in Saline county. Agriculture probably is first in importance because it employs more people, the total value of its product is as large, and practically the entire area of the county is utilized in its pursuit. The system of farming which has been practiced since the county was settled has been that of general grain farming, and as a whole it has been profitable. Some farms, however, have been abandoned and more are being abandoned each year because the land has passed the point of marginal utility; that is, the point at which, under present conditions of agriculture, they can be profitably operated. One-third of the acreage in the county is not suited to general grain farming, and unless some specialized crops are introduced this large acreage will pass the point of being profitable and become submarginal land. The areas referred to as marginal lands are the rough and rocky hillsides, the slopes from which fertile surface soil is removed each year by erosion, and land which has been so farmed that it no longer produces profitable crops. Special crops which are adapted to this marginal land are pasture, fruit, and forest.

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In 1919, as shown by the Fourteenth Census, there were 2,105 farms in Saline county, these having an average of 97 acres each, 84.2 acres of which were improved. In 1900 the number of farms reported was 2,912, showing a rapid decrease during the two decades. Tenantry also decreased 50 percent during this time, 76.3 percent of the farms being operated in 1919 by the owners.

The principal crops are corn, wheat, oats, cowpeas, pasture, and hay. The Census reports the following acreage and yield of the more important crops.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	34,342	692,567 bu.	20.0 bu.
Wheat	29,276	387,403 bu.	13.0 bu.
Oats	11,295	208,270 bu.	18.0 bu.
Barley	16	156 bu.	9.7 bu.
Rye	265	1,800 bu.	6.8 bu.
Timothy	8,279	9,839 tons	1.2 tons
Timothy and clover mixed	4,398	5,084 tons	1.1 tons
Clover	3,025	3,549 tons	1.2 tons
Alfalfa	876	1,421 tons	1.6 tons
Silage crops	342	1,472 tons	4.3 tons
Corn for silage	2,730	5,955 tons	2.1 tons

Within the past few years the cowpea, grown for both hay and seed, has been rapidly establishing itself as one of the staple crops of the region. The total value of the grains, hay and seed, produced in 1919 was slightly more than three million dollars. It must be remembered that these figures are for but a single year, that of 1919, which appears to have been a poor crop year for corn and oats. The U. S. Department of Agriculture reports the following acre-yields for the ten-year period 1911-1920, for Saline county: corn, 26.8 bushels; oats, 23.9 bushels; tame hay, 1.04 tons; winter wheat, 13.0 bushels.

The livestock interests, including those of dairy and poultry, are of importance, as is shown by the following data, also taken from the 1920 Census.

Animals and Animal Products	*Number*	*Value*
Horses	5,697	$538,225
Mules	3,289	382,899
Beef cattle	4,578	219,710
Dairy cattle	7,313	391,272
Sheep	1,995	26,284
Swine	17,210	218,967
Poultry	159,723	141,964
Eggs and chickens	.....	416,861
Dairy products	.....	277,376
Wool	5,219 lbs.	2,939

The report gives the total value of livestock as more than two and one-half million dollars.

Very little interest has been shown in the growing of fruit until the past few years. Prior to 1920 no fruit was grown for sale outside the county; since then orchards have been set out and have returned good profits. About 52,000 quarts of small fruits were produced in 1919. The total production of orchard fruits—namely, apples, pears, peaches, and cherries—was approximately 80,000 bushels, three-fifths of which were apples. Thirty thousand pounds of grapes were produced.

SOIL FORMATION

GEOLOGICAL HISTORY

A belt of high, rough land, which is commonly referred to as a spur of the Ozarks, enters Saline county in the southwestern corner, stretching across the southern tier of townships in a northeasterly direction. The history of this area dates back to the later Paleozoic period of geological time. It was not covered by any advance of ice during the Glacial period, and for that reason is termed unglaciated. The surface rocks of this area have been exposed to the processes of weathering longer than those in other parts of the state. This area is the result of a series of uplifts, the remains of which are shown by disconnected plains of about the same level and extent. The first uplift now forming the crest of the ridge appears in Saline county in the southeastern corner. The few isolated peaks forming the remnants of this plain stand about 1,000 feet above sea level, and are the highest points in the county. These ridges are made up of diverse rocks, the remaining high knobs being resistant sandstone, while limestone and shales, which are more easily weathered, form the valleys.

The most important period in the geological history of that part of the county north of this rugged area is known as the Glacial period. At that time snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an amount that the mass pushed outward from these centers, chiefly southward, until a point was reached where the ice melted as rapidly as it advanced. In moving across the country from the far north, the ice gathered up all sorts and sizes of materials, including clay, silt, sand, boulders, and even immense masses of rock. Some of these materials were carried for hundreds of miles and rubbed against surface rocks and against each other until largely ground to powder.

A pressure of 40 pounds a square inch is exerted by a mass of ice 100 feet thick, and these ice sheets were hundreds, or possibly thousands, of feet in thickness. The material carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys filled with debris, and the surface features were changed entirely. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift. The average depth of this deposit over the state of Illinois is estimated at more than one hundred feet.

During the Glacial period at least six distinct ice advances occurred that were separated by long periods of time. Only one of these, designated as the Illinoisan, reached Saline county. All the county except the rugged area lying south of the valley of the South Fork of Saline river was covered by this glacier. Previous to the ice invasion the glaciated region generally was not well suited to agriculture because of its rough and hilly character, as is shown by numerous borings which indicate that erosion had completely dissected the land. The general effect of the glaciers was to change the surface from hilly to gently undulating. Erosion has since continued active and has changed the topography in some areas from undulating back to hilly again.

The deposit of drift left by the Illinoisan glacier varied in depth from a few inches on the tops of old knolls or hills to a depth of 50 to 100 feet in old stream valleys. The drift was a heavy, sandy, gravelly, compact clay, originally blue but now more yellowish, owing to weathering. When the limit of the advance of the Illinoisan glacier was reached, the material carried by the glacier did not accumulate in a broad undulating ridge or moraine, as was the case with other glacial advances, because the thickness of the glacier and the amount of material it carried were greatly reduced by the time it reached Saline county, and its recession was gradual and uniform rather than intermittent, as was the case of those glaciers which built up moraines.

Another important process took place during and shortly after the Glacial period, which furnished a large part of the soil material from which the present soils were derived. During the melting of the glaciers, the Illinoisan as well as subsequent ones, the streams were overloaded with rock flour produced by the grinding action of the glacier. This rock flour was deposited in the stream valleys, and after the streams regained their former channels, it dried, was picked up by the wind, and was rather uniformly deposited over the upland as dust. Saline county received its share of this wind-blown material, called loess, which buried the older deposits to a depth varying from one to twenty feet.

The broad, flat valleys which are found along the main drainage courses are not the result of stream erosion since the Glacial period. Altho the Illinoisan glacier, in its advance across Saline county, covered the land with a deposit varying from a few inches to more than 100 feet, the deposit had little effect on the present general drainage of the county. The main drainage channels were reestablished along Preglacial lines and the streams have taken meandering courses thru these broad valleys which have been filled to a depth of 50 to 100 feet with drift. These valleys are termed Preglacial because they are the result of stream erosion since the area was first lifted out of the sea at a very early geologic period. The Preglacial valleys comprize more than one-third of the total area of the county, and contain the more fertile and productive soils.

PHYSIOGRAPHY AND DRAINAGE

Saline county has extremes in topography which are due primarily to the rugged, hilly character of the Ozark highlands. This area is extremely rough and broken; erosion has dissected the once extensive plains until now only a few very narrow ridges remain as comparatively level land. The glaciated area to the north of the Ozark ridge is flat to gently rolling except for a few areas along the west side of the county which are rolling to rough. The broad stream valleys are nearly level, the bordering lowlands undulating, and the upland gently rolling.

The altitude of Saline county varies from 980 feet above sea level to 340 feet, a difference of more than 600 feet. The highest point is on Horton Hill near the southern part of Sommerset township, (Township 10 South, Range 7 East); the lowest point is found where Saline river leaves the county. The following figures give the altitudes of a few points in the county: Bald Knob, 820 feet;

Eldorado, 385; Francis Mills, 371; Galatia, 416; Harrisburg, 366; Horton Hill, 980; Raleigh, 418; Rileyville, 393; Rudemont, 400; Sommerset, 446.

The county lies entirely within the drainage basin of Saline river, the waters of which flow east, emptying into the Ohio river. South Fork drains the three southern townships with the exception of the east half of Sommerset township (Township 10 South, Range 3 East), which is drained by Eagle creek; Middle Fork with its tributary, Bangston creek, drains the central and western parts of the county; and North Fork with its tributary, Rector creek, drains the northeastern part of the county. South Fork and Middle Fork unite just east of the center of the county to form Saline river.

The county is generally well drained, each of the larger streams having numerous tributaries which drain every section. Judging from the ramification of streams, the amount of erosion, and the breadth and depth of stream valleys, the drainage of Saline county would be classed as mature. The unglaciated area drains particularly well, owing to the hilly topography. The problem here is not one of drainage but one of controlling the erosion which occurs as a result of surface run-off. Except for a few flat areas the glaciated upland drains well, erosion becoming a problem on the more rolling topography. Heavy spring rains

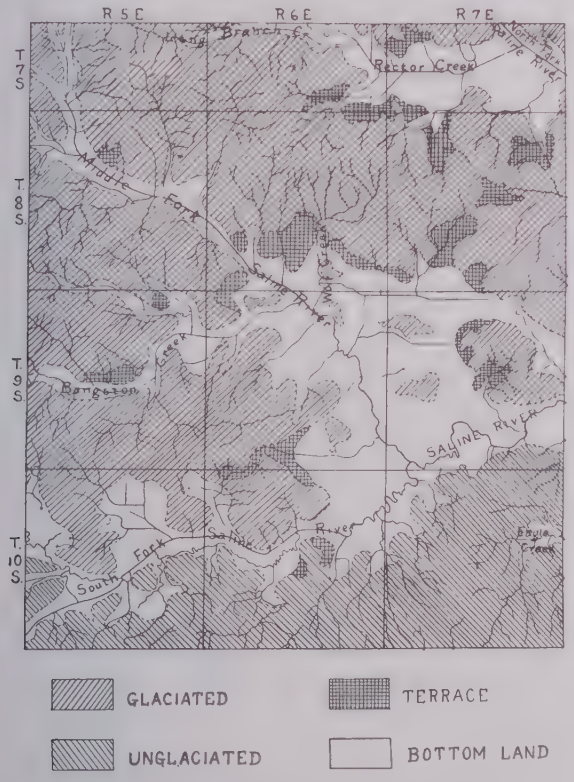


FIG. 1.—DRAINAGE MAP OF SALINE COUNTY SHOWING STREAM COURSES, GLACIATED AND UNGLACIATED AREAS, TERRACE, AND BOTTOM LAND

fill the stream channels and the streams frequently overflow the surrounding bottom land, making shallow lakes which do not dry up until summer. Extensive dredging has improved this condition materially, but more improvement could be effected, especially by deepening and widening those dredges already in. The system should be extended until it reaches every farm, since much of the land in these broad valleys remains swampy thruout the year.

SOIL DEVELOPMENT

Rocks weathered in place, glacial till, and loess are the three sources of soil material from which the present upland soils of Saline county were derived. The present soil is thought to have been derived mainly from material of loessial origin. On the stony slopes in the unglaciated part of the county are some areas where the soil material is a mixture of residual and loessial material, and might properly be termed residuo-loessial or residuo-æolial. Erosion has, subsequently, removed the loess from some of the hilly areas in the glaciated region so that the till forms the soil material in those areas.

The general composition of any soil material, particularly loess, is rather uniform when first deposited. The various physical, chemical, and biological agencies of weathering form soil out of soil material by some or all of the following processes: the leaching of certain elements, the accumulation of others; the chemical reduction of certain compounds, the oxidation of others; the translocation of the finer soil particles, and the arrangement of them into layers, zones or horizons; and the accumulation of organic matter from the growth and decay of vegetable material.

One of the very pronounced characteristics observed in most soils is that they are composed of distinct layers, strata, or horizons, and so, as explained on page 22, these horizons are named, from the surface down: A, the layer of extraction; B, the layer of concentration or accumulation; and C, less-altered material, or the layer in which weathering has had less effect. The development of horizons in a soil is an indication of its age. Bottom-land soils which are constantly receiving deposits washed down from the adjoining hills are called young soils; new soil material is added so frequently that the process of weathering does not have time to form distinct horizons. Some of the areas in the broad preglacial bottom lands of Saline county do not overflow often and have not received any additional deposit of consequence for many years; the soils in these areas have developed horizons but they are not so mature as those of the upland.

SOIL GROUPS

The soils of Saline county are divided into four groups, as follows:

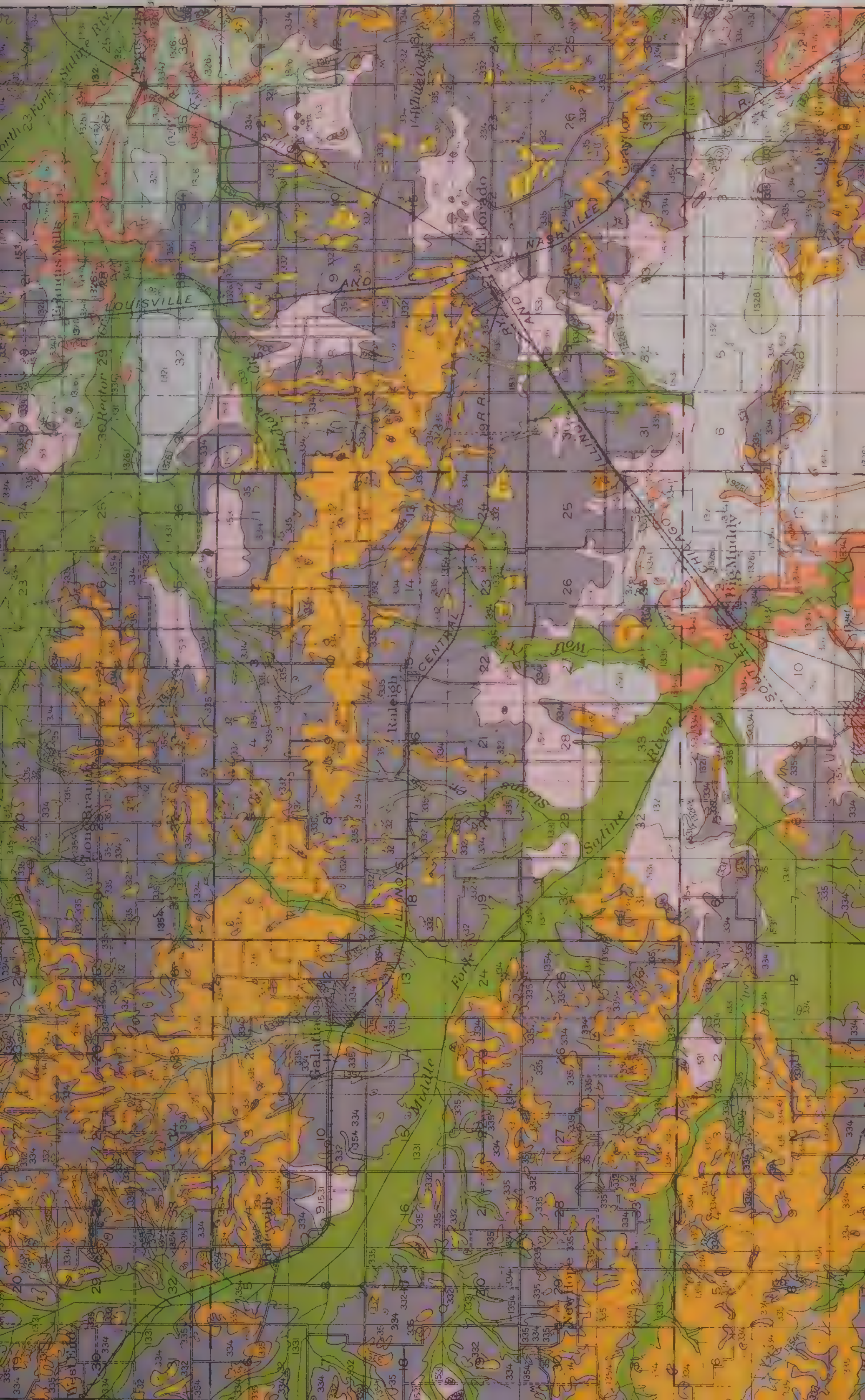
Upland Timber Soils, including all the upland areas of glacial or loessial origin, that are now, or were formerly, covered with timber.

Terrace Soils, including bench lands, or second bottom lands, formed by deposits from overloaded streams.

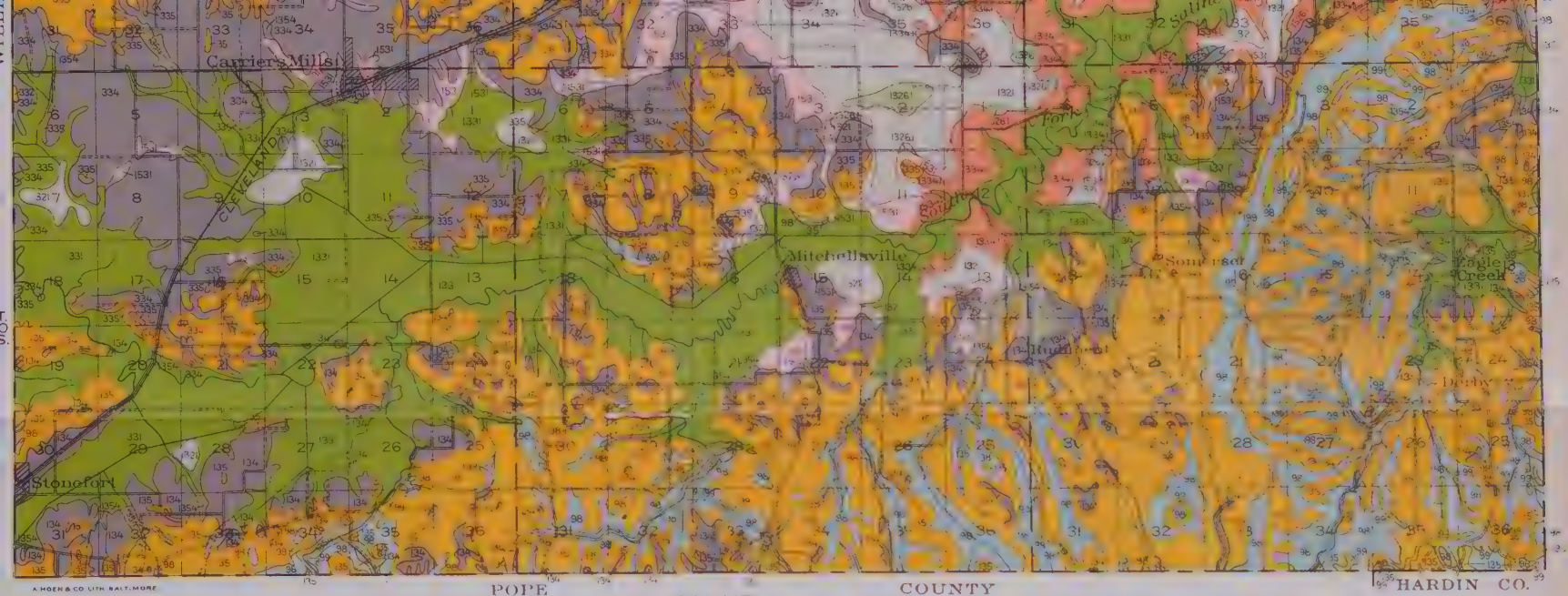
Swamp and Bottom-Land Soils, including the overflow land along streams, the swamps, and poorly drained lowlands.

Residual Soils, including rock outcrops, and soils formed in place thru the weathering of rocks.

GALLATIN



Eldorado
Raleigh
Galatia
New Hope
West End
Big Muddy
LOUISVILLE
AND
NASHVILLE
ILLINOIS
CENTRAL
Saline
River
Middle
Fork
Rector



000 Residual
100 Unglaciated Areas
300 Lower Illinoisan Glaciation

Scale
0 ⅛ ½ 1 2 Miles

LEGEND

UPLAND TIMBER SOILS
- Yellow-Gray Silt Loam
- Yellow Silt Loam
- Light Gray Silt Loam On Tight Clay

1500 TERRACE SOILS
- Deep Gray Silt Loam

CONVENTIONAL SIGNS
- Railroads
- Public Roads
- Private Roads
- Township Lines

1300 OLD SWAMP AND BOTTOMLAND SOILS
- Deep Gray Silt Loam
- Mixed Loam
- Drab Clay Loam
- Yellow-Gray Silt Loam On Clay
- Brown Silt Loam On Clay

RESIDUAL SOILS
- Stony Loam
- Rock Outcrop
- Small Areas Of Stony Loam
- Small Areas Of Rock Outcrop

SOIL SURVEY MAP OF SALINE COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

TABLE 1.—SOIL TYPES OF SALINE COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Timber Soils (100, 300)			
134 } 334 }	Yellow-Gray Silt Loam	119.40	76 416	30.88
135 } 335 }	Yellow Silt Loam	91.58	58 611	23.68
332	Light Gray Silt Loam On Tight Clay	2.80	1 792	.72
		213.78	136 819	55.28
	Terrace Soils (1500)			
1531	Deep Gray Silt Loam	22.77	14 573	5.89
	Old Swamp and Bottom-Land Soils (1300)			
1331	Deep Gray Silt Loam	70.20	44 928	18.15
1354	Mixed Loam	11.59	7 418	3.00
1321	Drab Clay Loam	30.17	19 309	7.80
1334.1	Yellow-Gray Silt Loam On Clay	16.21	10 374	4.19
1326.1	Brown Silt Loam On Clay	8.96	5 734	2.32
		137.13	87 763	35.46
	Residual Soils (000)			
098	Stony Loam	12.45	7 968	3.22
099	Rock Outcrop	.57	365	.15
		13.02	8 333	3.37
	Total	386.70	247 488	100.00

Table 1 gives a list of the soil types found in Saline county, classified according to the groups described above. It also shows the area of each type in square miles and in acres and its percentage of the total area of the county. The accompanying map shows the location and boundary lines of every type of soil in the county, even down to areas of a few acres in extent.

For explanations concerning the classification of soils and the interpretation of the maps and tables, the reader is referred to the first part of the Appendix to this report.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN SALINE COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose, samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). These sampling strata correspond approximately in the common kinds of soil to 2 million pounds per acre of dry soil in the upper stratum and to two times and three times this quantity in the middle and lower strata, respectively. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quan-

tity and distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to in describing the soil types as surface, subsurface, and subsoil. By this system of sampling we have represented separately three zones for plant feeding. The upper, or surface layer, includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, and other fertilizing materials are incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed. It should be understood, however, that the rate of liberation from their insoluble forms, a matter of at least equal importance, is governed by many factors, and is therefore not necessarily proportional to the total amounts present.

For convenience in making application of the chemical analyses, the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In doing this the assumption is made that for ordinary types an acre of soil to a depth of 6⅔ inches weighs 2 million pounds. It is understood, of course, that this value is only an approximation, but with this understanding it is believed that it will suffice for the purpose intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires to consider the information in that form.

With respect to the presence of limestone and acidity in defferent strata, no attempt is made to include in the tabulated results figures purporting to represent their averages for the respective types, because of the extreme variations frequently found within a given soil type. In examining each soil type in the field, however, numerous qualitative tests are made which furnish general information regarding the soil reaction, and in the discussion of the individual soil types which follows, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping and soil treatment. It is often desirable, therefore, to determine the lime requirement for a given field, and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (page 29).

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amounts of organic carbon and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil of each type in Saline county.

In connection with this table attention is called to the variation among the soil types with respect to their content of the different plant-food elements. It will be seen from the analyses that a variation in the organic-carbon content of the different soils is accompanied by a parallel variation in the nitrogen content. The organic-carbon content, which serves as a measure of the total organic

matter present, is usually from 10 to 12 times that of the total nitrogen. This close relationship is explained by the well-established facts that all soil organic matter contains nitrogen, and that most of the soil nitrogen (usually 98 percent or more) is present in a state of organic combination. This close relationship is also maintained in the middle and lower sampling strata.

The organic matter, with the accompanying nitrogen, shows some variation among the different soil types but is comparatively low thruout the county. Of the nine types of soil for which analyses are reported in this county, only one contains more than 40,000 pounds of organic carbon in the surface stratum of an acre. This is Drab Clay Loam, Bottom, which contains 46,410 pounds of this element, with a corresponding nitrogen content of 3,710 pounds an acre. The remainder of the soils in the county range from 34,480 pounds of organic carbon in Brown Silt Loam On Clay, down to 15,720 pounds in Yellow Silt Loam. The total nitrogen values are correspondingly low, being in the two latter types 2,800 and 1,340 pounds respectively. Because of the small amounts of both nitrogen and organic matter in these soils, it is particularly important to grow legume crops frequently as green manures and plow them down, in addition to conserving and using all the animal manure which can be produced.

Other elements are not so closely associated with each other as organic matter and nitrogen. There is some degree of correlation, however, between sulfur, another element used by growing plants, and organic carbon. This is because a considerable, tho varying, proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of the organic matter. The sulfur content of Saline county soils is generally low. It ranges, in the surface soil, from 60 to 660 pounds an acre, averaging less than half the phosphorus content. The proportion is still lower in the deeper layers of soil. This is partly accounted for by the low organic matter. Another factor is the atmospheric supply. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently it is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption the amount of sulfur thus added to the soil is relatively large. At Urbana, during the eight-year period from 1917 to 1924, there has been added to soil by the rainfall 3.5 pounds of sulfur an acre a month as an average. Similar observations have been made in localities in southern Illinois for shorter periods. At Newton, in Jasper county, in 1921 there was added in the rainfall 2.52 pounds of sulfur an acre in June and 3.75 pounds in September. At Ewing, Franklin county, during the season of 1921 the average monthly precipitation contained 2.27 pounds of sulfur an acre. These figures will afford some idea of the amount of sulfur added by rain and also of the wide variation in these amounts under different conditions. On the whole, these facts would indicate that the sulfur added from the atmosphere supplements that contained in the soil, so that there is probably no need for sulfur fertilizers in Saline county. Because of the possibility of a need for sulfur fertilization in some parts of the state, experiments with gypsum have been started on five experiment fields, namely, Raleigh, Toledo, Carthage, Hartsburg, and Dixon. The first two named fields are located in southern Illinois, in Saline and Cumberland counties, respectively.

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF SALINE COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES
Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Timber Soils (100, 300)							
134, 334	Yellow-Gray Silt Loam	21 570	2 110	860	350	24 230	5 210	4 670
135, 335	Yellow Silt Loam	15 720	1 340	660	280	30 490	6 420	4 440
332	Light Gray Silt Loam On Tight Clay	17 720	1 620	680	340	25 480	4 600	5 140
	Terrace Soils (1500)							
1531	Deep Gray Silt Loam	24 710	2 360	970	380	30 720	6 170	6 720
	Old Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam	20 490	2 160	1 100	460	33 890	7 080	5 060
1354	Mixed Loam[1]							
1321	Drab Clay Loam	46 410	3 710	1 280	660	40 790	14 230	16 250
1334.1	Yellow-Gray Silt Loam On Clay	21 920	1 760	850	420	33 750	7 410	5 800
1326.1	Brown Silt Loam On Clay	34 480	2 800	820	440	35 580	10 480	13 100
	Residual Soils (000)							
098	Stony Loam	19 960	1 180	520	60	22 880	4 040	4 300
099	Rock Outcrop[2]							

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.
[2]No samples taken.

The phosphorus content of the soils in the county is low, on the whole, averaging only about 850 pounds an acre in the surface soil. Drab Clay Loam contains 1,280 pounds an acre of this element, while the minimum, 520 pounds, is found in Stony Loam. Considering the low phosphorus level in these soils it appears that the renewal of this element by the addition of phosphate will be a necessary step in the permanent improvement of the soil.

The potassium content of the soil ranges from 22,880 pounds an acre in Stony Loam to 40,790 pounds in Drab Clay Loam. From a quantitative point of view the least of these amounts is far above maximum crop requirements. However, the rate at which potassium is liberated in available condition from these large reserves is slow, and in soils so low in organic matter as is the case here the rate of liberation may be too slow to supply the needs of growing crops. The results of field experiments as given in the Supplement are an indication that potassium fertilization may be desirable, at least for some crops on some of the soils of Saline county.

The amounts of soil calcium are, on the whole, rather low, but no lower than is to be expected in old, leached soils which are strongly acid. Soil acidity and calcium deficiencies are very frequently, but not always, associated. The

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF SALINE COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Timber Soils (100, 300)							
134, 334	Yellow-Gray Silt Loam	23 930	2 710	1 530	510	54 520	16 260	8 160
135, 335	Yellow Silt Loam	16 830	1 760	1 470	530	63 510	17 620	8 720
332	Light Gray Silt Loam On Tight Clay	14 040	1 320	1 160	360	51 880	11 240	9 720
	Terrace Soils (1500)							
1531	Deep Gray Silt Loam	24 140	2 460	1 420	600	61 840	13 360	11 960
	Old Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam	18 340	2 440	1 740	640	70 020	14 570	9 970
1354	Mixed Loam[1]							
1321	Drab Clay Loam	56 460	4 730	1 930	790	81 290	27 960	24 900
1334.1	Yellow-Gray Silt Loam On Clay	18 580	1 720	1 400	780	74 040	20 860	8 320
1326.1	Brown Silt Loam On Clay	41 280	3 400	1 120	840	70 040	22 960	23 240
	Residual Soils (000)							
098	Stony Loam[2]							
099	Rock Outcrop[3]							

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of Mixed Loam, chemical data for this type are not included.

[2]The stony character of this type prevented the sampling of the middle stratum.

[3]No samples taken.

smallest amount of calcium, 4,300 pounds an acre, is in Stony Loam; but this amount, with two exceptions, is about the same as that in all the other types. These two exceptions are Brown Silt Loam On Clay, with 13,100 pounds, and Drab Clay Loam, with 16,250 pounds. Both of these are bottom-land types which are neutral or alkaline. Calcium is utilized by crops in fairly large amounts, so that in soils low in calcium content this element may not become available rapidly enough to supply crop needs. The liming of such soils, however, supplies any calcium deficiencies in addition to the correcting of acidity.

The surface soil in Saline county contains, on the average, approximately the same quantity of magnesium as of calcium. The smallest amount found is 4,040 pounds an acre and the maximum 14,230 pounds. Because of the relatively small quantities of this element required by crops, it is doubtful, even in soils containing the minimum, whether it ever becomes a limiting factor in crop growth. Moreover, any possible deficiencies of this element for crop growth in the surface soils are offset by the accumulations in the lower strata, as explained in the following section.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper stratum, or with each other, it is necessary to bear in mind that the data as given for the middle and lower sampling strata are on the basis of 4 million

TABLE 4.—PLANT-FOOD ELEMENTS IN SOILS OF SALINE COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Timber Soils (100, 300)							
134 334	Yellow-Gray Silt Loam	19 420	2 390	2 350	570	94 730	34 470	18 540
135 335	Yellow Silt Loam	12 210	1 780	2 050	890	96 090	27 810	15 880
332	Light Gray Silt Loam On Tight Clay	14 460	1 560	1 860	60	84 720	27 000	15 840
	Terrace Soils (1500)							
1531	Deep Gray Silt Loam	24 240	2 940	1 920	360	97 800	27 030	20 220
	Old Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam	17 170	2 760	2 200	540	107 220	22 210	15 250
1354	Mixed Loam[1]							
1321	Drab Clay Loam	49 710	4 780	2 730	1 000	120 210	50 790	45 700
1334.1	Yellow-Gray Silt Loam On Clay	20 730	2 430	2 430	1 830	120 060	47 220	17 880
1326.1	Brown Silt Loam On Clay	37 440	3 720	2 160	680	109 740	50 340	48 360
	Residual Soils (000)							
098	Stony Loam[2]							
099	Rock Outcrop[3]							

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of Mixed Loam, chemical data for this type are not included.
[2]The stony character of this type prevented the sampling of the lower stratum.
[3]No samples taken.

and 6 million pounds of soil, and should, therefore, be divided by two and three respectively before being compared with each other or with the data for the upper stratum, which is on a basis of 2 million pounds.

With this in mind it will be noted in comparing the three strata with each other that all the soil types diminish rather rapidly in organic matter and nitrogen with increasing depth, and that this diminution is very marked even in the middle stratum. The sulfur content decreases markedly with increasing depth. This is to be expected since a portion of the sulfur exists in combination with the soil organic matter, and inorganic forms of sulfur are not tenaciously retained by the soil against the leaching action of ground water. Phosphorus, on the other hand, is not removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in these forms in plant residues at the expense of the underlying strata. Thus, in the eight soil types in Saline county analyzed, the second stratum contains proportionately a smaller amount of phosphorus than the surface.

The basic elements have all been leached from the surface soil to some extent. Potassium and magnesium show increases in the second stratum and are still more concentrated in the lowest. As these bases are dissolved from the surface soil and pass downward by percolation, they are in part fixed in

the lower levels by reconversion into insoluble forms. Calcium is less readily fixed than magnesium. Consequently the latter forces calcium out into the solution so that it is carried down to lower levels or lost entirely. It is to be noted that in nearly all the soil types in Saline county the accumulation of calcium occurs only in the lowest stratum or not at all, while magnesium and potassium exhibit increases in concentration also in the second stratum.

It is frequently of interest to know the total supply of a plant-food element within reach of the roots of growing crops. While it is impossible to obtain this information exactly, especially for the deeper-rooted crops, it seems probable that practically all the feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil type the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

Considered in this manner the tables reveal a wide variation with respect to the relative abundance of the various elements among the different soil types, as measured by crop requirements. We may compare in this way two extreme soil types in the county, namely, Drab Clay Loam, Bottom, and Yellow Silt Loam, Upland. These are among the most extensive soil types in the county. The respective amounts of nitrogen in the two soils to a depth of 40 inches are 13,220 and 4,880 pounds an acre, which is equivalent to the nitrogen contained in the same number of bushels of corn, since a bushel of corn contains approximately a pound of nitrogen. Drab Clay Loam thus contains nearly three times as much of this element as Yellow Silt Loam. Drab Clay Loam also contains considerably more phosphorus than Yellow Silt Loam. The former contains 5,940 pounds of phosphorus, which is equivalent to 34,900 bushels of corn, as compared to 4,180 pounds in the latter, equivalent to 24,600 bushels of corn. A comparison of total amounts of potassium in the two soil types is of little moment when it is considered that the soil with the lowest content of this element, namely, Light Gray Silt Loam On Tight Clay, contains potassium equivalent to 850,000 bushels of corn. This large total supply of potassium does not mean that there can be no need for potassium fertilizers. The supply in the soil may not become available rapidly enough for the demands of crops during the growing season, and therefore in some cases applications of potassium may prove beneficial.

These two soil types vary widely in calcium content, the amounts contained to a depth of 40 inches being 86,850 pounds in Drab Clay Loam and only 29,040 pounds in Yellow Silt Loam. The relative amount of calcium is not of so great importance directly in connection with the corn crop as it is with respect to legumes. A ton of red clover hay, for example, contains approximately 29 pounds of calcium. These two soils therefore contain as much calcium as would be removed in 2,990 and 1,000 tons of red clover hay respectively.

The above statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors than the amount of plant-food elements present enter into consideration.

Much depends upon the nature of the crops to be grown, as to their ability to utilize plant-food materials, and much depends upon the condition of the plant-food substances themselves, as to their availability. Finally, in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such chemical data do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon, and in this way contribute fundamental information for the intelligent planning, in a broad way, of systems of soil management that will conserve and improve the fertility of the land.

DESCRIPTION OF SOIL TYPES

UPLAND TIMBER SOILS

The upland timber soils include all the upland areas of glacial and loessial origin that are now or were formerly covered with timber. In forests the vegetable material from trees falls on the surface of the ground and is either burned or suffers almost complete decay. Grasses, which furnish large amounts of humus-forming roots, do not grow to any extent because of the shade. Moreover, the organic matter that had accumulated before the timber invaded the territory is removed thru various decomposition processes, with the result that in these soils generally the content of nitrogen and organic matter is low. A yellowish or yellowish gray surface color is characteristic of timber soils in Illinois.

The total area of upland timber soils in Saline county is 213.78 square miles, or more than 55 percent of the area of the county.

Yellow-Gray Silt Loam (134, 334)

Yellow-Gray Silt Loam has been formed under the influence of the long-continued growth of forests, which as a general rule develop along streams where drainage is good and gradually spread over the prairie as drainage becomes established. As this region is relatively old, ample time has elapsed for the timber to spread over the entire county. The topography of Yellow-Gray Silt Loam varies from undulating or nearly level to rolling. The topography of the area occupied by this type has been an important factor in the modification of certain horizons of the soil profile, producing different phases within the type. These phases are easily recognized, as (1) the undulating phase, whose soils have a distinct gray cast, and a compact to tight subsoil; (2) the rolling phase, whose soils are more yellowish, and not so compact. The rolling phase of Yellow-Gray Silt Loam is well drained naturally; it is much better drained than the undulating phase. The zone of accumulation, that is, the upper subsoil or B horizon, in the undulating phase is compact to tight and the soil is poorly aerated and poorly underdrained.

Yellow-Gray Silt Loam is the most extensive soil type in the county. It covers 119.4 square miles, or about 30 percent of the area of the county. The rolling phase includes all the areas of the type mapped in the unglaciated region, and those areas that occur on the slopes in the western part of the county and in the eastern part of Cottage Grove township (Township 9 South, Range 7 East).

Practically all the remaining areas of the type, except a few scattered ones, are included in the undulating phase.

The A_1 horizon, or surface soil, of the undulating phase of Yellow-Gray Silt Loam, 0 to 3 inches, or 6 to 7 inches when cultivated, is a brownish gray, friable silt loam. The A_2 horizon, or subsurface soil, 3 to 18 inches, is a light yellowish gray, mealy, friable silt loam. The B horizon, or upper subsoil, 18 to 34 inches, is a very compact to tight, well-mottled, yellow clay. Blotches of almost pure gray occur in the joints or cracks made by water percolating thru the soil. The C horizon, or lower subsoil, is a friable, mottled, yellow silt loam.

The A_1 horizon of the rolling phase of the Yellow-Gray Silt Loam, 0 to 5 inches, or 6 to 7 inches when cultivated, is a brownish yellow, friable silt loam. The A_2 horizon, 5 to 16 inches, is a friable, slightly mottled, yellowish gray silt loam. The B horizon, 16 to 30 inches, is a compact, grayish yellow, mottled, silty clay loam. The C horizon, below 30 inches, is a friable, yellow, mottled silt loam. The depth to till in the undulating phase of Yellow-Gray Silt Loam varies from 4 to 12 feet, while that in the rolling phase is more constant and averages about 5 feet.

Management.—The undulating phase of Yellow-Gray Silt Loam is not naturally well drained. It is usually medium to strongly acid in the surface soil and the degree of acidity increases with an increase in depth. It is low in organic matter and nitrogen. Red clover will not grow on this land unless it is either limed or heavily manured. Sweet clover will not grow without lime. Cowpeas do fairly well without lime and mixed clover and timothy hay yields well following the application of 3 to 4 tons of limestone per acre.

The results on the Raleigh experiment field, which is located on soil similar to much of this phase of the type, indicate that manure or residues without lime are not effective, but that if lime also is used the response of the crops is good. Rock phosphate has not caused sufficient increase in yields on this field to pay its cost. Potash has caused sufficient increase in yields to indicate that it is worth while to try small applications of one of the potash salts for corn. The outstanding requirements of this soil type are first lime and then fresh organic matter and nitrogen secured by the growth of clover, preferably sweet clover, and the use of all manure available. Further studies now in progress indicate that other treatments may prove profitable, in addition to those that can now be definitely recommended.

The rolling phase of Yellow-Gray Silt Loam is better drained than the undulating phase because of its more rolling topography and more pervious subsoil. It is similar to it in lime requirement except that the subsoil is probably always less acid, and it is also low in nitrogen and organic matter. The Elizabethtown experiment field is located on soil which is similar to this phase of the type. The results secured on this field indicate no improvement in yield from the use of manure or residues alone. A very marked increase in yield, however, follows the application of limestone with either manure or residues. Rock phosphate has produced a more beneficial effect on this field than on the Raleigh field, but the increase in yields resulting from its application are not sufficiently high to justify its unqualified recommendation for the soil under

discussion. It can be stated, however, that the results from its use on this kind of soil are sufficiently good to indicate very strongly the wisdom of giving it a trial after the lime, nitrogen, and organic-matter deficiencies of the soil have been corrected. Comparative phosphate trials have been conducted on the Elizabethtown field for a short time. This work has not been in progress sufficiently long to warrant drawing conclusions. To date the differences shown are small. The potassium treatment on this field has been ineffective.

Yellow Silt Loam (135, 335)

Yellow Silt Loam is the predominating soil type in the unglaciated region, and is also well distributed over the remainder of the county. It occurs in very irregular areas as the broken and hilly land along streams, in the more rolling and rough upland, and on the steep slopes of ridges. It has been heavily timbered, and some of the timber has never been cut off. Yellow Silt Loam is the second most extensive soil type in the county and covers an area of 91.58 square miles.

The A_1 horizon, or surface soil, when present, is a reddish to brownish yellow, friable, silt loam. Sheet washing and gullying have removed the true surface soil in most cases. The A_2 horizon, or subsurface soil, is a yellowish gray, friable, silt loam, varying in thickness from 0 to 15 inches, depending on how much erosion has taken place. The B horizon, or upper subsoil, is a compact, mottled reddish yellow, silty clay loam, found at a depth of 15 to 30 inches in areas where erosion is not active. The C horizon, or lower subsoil, is a friable, yellow, mottled silt loam. Often in the glaciated areas glacial till forms the subsoil, and in the unglaciated areas, cherty, residual material is found.

Management.—The management of Yellow Silt Loam must be governed by the slope as well as by the character of the soil material of the particular area in question. A large proportion of the type is unsuited to ordinary farming because of its steep topography and consequent tendency to erode. The steepest portions should be utilized for timber growth; other portions are well adapted to orcharding, while still others can be made into excellent pastures provided limestone can be applied. The slopes which are not so steep as to present too difficult erosion problems may be farmed successfully if constant attention is given to controlling erosion. The results secured on the Vienna experiment field (see page 51 of the Supplement) may be taken as an indication of the success which will follow the use of limestone and good farming methods. This land, when treated with limestone, is particularly well adapted to hay, either clover or mixed clover and timothy. It also grows excellent cowpeas and fair wheat. It is not adapted to corn. The results from the Vienna field do not indicate that either rock phosphate or acid phosphate will be profitable on this soil when manure also is applied. No information is available as to whether either of these phosphates could be used profitably with a good rotation, including clover, when manure is not used.

Light Gray Silt Loam On Tight Clay (332)

Light Gray Silt Loam On Tight Clay is one of the poorest upland types in the county. It occupies only 2.8 square miles, occurring in the flat, poorly

drained, timbered areas in the glaciated portion of the county. It is commonly referred to as "post oak or hickory flats," because post oak and hickory trees grow in abundance on the land. This type is too flat for proper surface drainage, the subsoil is so tight that underdrainage is impossible, and organic matter is deficient. It has a profile similar to that of Gray Silt Loam On Tight Clay, but differs from it in that the surface and gray layer are lighter in color and better developed, and that the B horizon or "tight clay," is less yellow and appears to be more plastic and impervious.

The A_1 horizon, or surface soil, of Light Gray Silt Loam On Tight Clay, 0 to 5 inches, is a friable, light yellowish gray silt loam. The A_2 horizon, or subsurface soil, 5 to 23 inches, is a friable, mealy, light gray silt loam. The B_1 horizon, or upper subsoil, 23 to 36 inches, is a gray clay mottled with light yellow. The C horizon, or lower subsoil, below 36 inches, is a slightly compact, well-mottled, yellowish gray silt loam. The till is encountered at an average depth of 6 feet. The low organic-matter content of this type makes it run together during heavy rains. The soil works fairly well when moist but bakes very hard on drying. The surface is somewhat porous and incoherent. Hydrated iron oxide concretions are usually found in abundance on this soil type.

Management.—Light Gray Silt Loam On Tight Clay is strongly acid and very low in nitrogen and organic matter. It is not a good general farm soil because of unfavorable moisture conditions resulting from its highly impervious nature.

Results obtained on the Sparta experiment field which is located, for the most part, on Light Gray Silt Loam On Tight Clay, indicate that limestone is essential on this type. Manure when used alone causes but little increase in yield, but limestone and manure together, or limestone and crop residues, cause a sufficient increase in yield to return a profit on the money invested in limestone. Neither rock phosphate nor potash caused sufficient increase in yield to pay for their cost. See page 47 of the Supplement for further discussion of the Sparta experiment field.

Attention should be called to the fact that the areas of this soil type in Saline county are flat, while the Sparta field has sufficient slope so that good surface drainage can be provided. This difference in topography suggests that the Saline county areas will not respond to any treatment so well as the Sparta field does. Further, it is questionable whether an attempt should be made to use this type for general farming. The gross returns, even under the best treatment, are small. It is suggested that it be used either for apples or for pasture with sweet clover as the pasture crop.

TERRACE SOILS

The terrace soils of Saline county occur either as bench land along stream valleys, or just above overflow in the valley itself. The bench-land terraces were formed chiefly by the deposition of silt washed down from the surrounding upland, mixed with some alluvial deposit carried in many years ago. Swollen and overloaded streams caused by the melting of the glacier, and subsequent heavy rains, flooded the valleys and filled them to a depth of 10 feet or more with an alluvial deposit. Gradually the streams cut deeper channels thru this

deposit, leaving parts of it above overflow. These parts are known as terraces or second bottoms. In Saline county there is but a single terrace type, Deep Gray Silt Loam (1531), and it occupies 22.77 square miles.

Deep Gray Silt Loam (1531)

Deep Gray Silt Loam, Terrace, is found for the most part along small creeks, and is rather generally distributed over the county. A few areas included in this type overflow in exceptionally high water. Not enough deposit is left, however, to change the soil, as most of the water rises from the immediate vicinity and is gone in a few hours. The soil profile of this type is in various stages of development, depending primarily upon the length of time which has elapsed since the deposition of the soil material. In general, the formation is relatively young in comparison with the mature upland. The more mature profile has the following description: the A_1 horizon, or surface soil, 0 to 4 inches, is a friable, yellowish gray silt loam; the A_2 horizon, or subsurface soil, 4 to 18 inches, is a friable, light gray silt loam; the B horizon, or upper subsoil, 18 to 24 inches, is a compact, somewhat plastic, gray clay loam. Often this layer is only partially developed. The younger soils which have no horizons developed are predominantly gray in color and silty in texture.

Management.—Deep Gray Silt Loam, Terrace, varies somewhat in lime requirement depending on whether it is subject to overflow. Those portions of the type which are overflowed at least once a year are either neutral or only slightly acid in the surface soil. The non-overflow portions of the type are usually medium acid in the surface. The subsoil of both the overflow and non-overflow portions is more strongly acid than the surface soil. This type is one of the best soils in Saline county. It needs lime, as indicated above, and is low in organic matter and nitrogen. No special treatment is advised at the present time other than attention to drainage, the use of limestone in such amounts as tests show are needed, and the use of leguminous crops, together with all the manure available.

OLD SWAMP AND BOTTOM-LAND SOILS

The most fertile land in Saline county is found in the broad, flat valleys. Most of it is an alluvial formation and is largely subject to overflow. Each overflow brings in some new deposit which serves continually to enrich the soil. The overflows do some damage to property, especially to growing crops, but they do not cause extensive damage as they usually occur in early spring before the land is prepared for crops, and recede quickly. This group of soils found in the valleys includes the bottom land along streams, the swamps, and the poorly drained lowlands. Drainage is the most important factor in the use of this land for agricultural purposes. In wet seasons water stands in all the low spots and on the level land, so saturating the soil for extended periods that plant development is seriously hampered. Dredging and tiling have relieved the condition in some areas. More of this work could profitably be done.

This group of soils is divided into five types which cover an area of 137.13 square miles, or about 35 percent of the total area of the county.

Deep Gray Silt Loam (1331)

Deep Gray Silt Loam is the common bottom-land soil of southern Illinois. It is generally distributed over this county and occupies areas varying in width from a few rods to more than a mile. It usually forms the overflow land immediately adjacent to streams. It overflows several times almost every year, and often receives a slight deposit of new material. Deep Gray Silt Loam, Bottom, covers an area of 70.2 square miles.

A soil which is continually receiving new deposit is not uniform, has no well-defined horizons, and is spoken of as a young soil. Deep Gray Silt Loam, Bottom, is a young soil and, as it varies considerably thruout its area, can be described only in general terms.

The surface soil, averaging about 6 inches but varying from 2 to 12 inches, is a friable, light yellowish gray silt loam. The areas near the present stream channels sometimes contain an appreciable amount of fine sand to a depth of 4 or 5 inches. Below the surface the soil is a friable, mealy, light gray silt loam. Areas which do not receive frequent deposits have developed a compact, silty clay horizon 2 or 3 inches thick which lies about 20 inches below the surface.

Management.—Deep Gray Silt Loam, Bottom, is a productive soil when the moisture conditions are such as to allow the normal growth of crops. The first considerations in its management are protection against overflow and provision for drainage. Both of these call for cooperative action.

The acidity of this type varies, depending on location with reference to the hilly region in the southeastern part of the county. The tributaries flowing out of this hilly region, in which a few limestone outcrops occur, apparently carry sufficient lime in solution to affect the reaction of the bottoms subject to overflow by their waters. These bottom lands vary from slight to medium in acidity, while the bottoms which receive overflow from the glaciated region to the north vary from medium to strong in acidity.

After the overflow problem has been taken care of, it is suggested that limestone be applied in accordance with the need as shown by tests, and that clover be grown as a source of nitrogen and organic matter, in both of which this soil is deficient. No mineral fertilizer treatment is advised at present, except on a trial basis.

Mixed Loam (1354)

Mixed Loam has been mapped in the bottom lands of the smaller streams, principally in the unglaciated area of the county. This type of soil is variable as to texture and composition, is subject to frequent overflow, and often the surface material is changed after a heavy rain. The type occupies 11.59 square miles.

Mixed Loam is the youngest soil in the county and has no true profile development. The surface soil is usually yellow in color. It is mostly silt but contains some coarse and fine sand. At about 20 inches the yellow color changes to gray and very seldom is there much sand present. Mixed Loam is usually well drained.

Management.—This type varies in degree of acidity. It is a productive soil, easily farmed because of its sand content, and should be managed in the same way as suggested for Deep Gray Silt Loam, Bottom.

Drab Clay Loam (1321)

Drab Clay Loam occupies the low, flat, and swampy land in the preglacial valleys, covering an area of 30.17 square miles. It overflows each year, the water forming shallow ponds which do not dry up until summer. It is an alluvial soil formed thru the deposition of the finer particles in back water or in water without current.

The surface soil to a depth of 4 to 6 inches is a plastic, black or dark drab clay loam. Often an inch or so of silt is found on the surface, owing to a recent deposit. Below this to a depth of 18 to 20 inches a heavy, plastic, grayish drab clay is found. Below 20 inches the soil changes to a very plastic, grayish yellow clay.

Management.—Drab Clay Loam is usually not acid, owing to frequent overflow. It is productive, but because of its heavy texture is not so easily farmed as the two preceding types. Tile, if installed, should probably be put not over 4 rods apart and 30 inches deep; thus installed, they would eliminate the open ditches which are now used to remove excess water. It is particularly important to maintain a good supply of fresh organic matter in this soil, as it tends easily to get into poor physical condition. The best utilization of this land requires that it be protected from flood water. After this protection has been afforded, then the nitrogen and organic matter needs of the soil may be met by growing clover at regular intervals, limestone may be applied as it becomes necessary, and tile may be installed as time and other considerations permit.

Yellow-Gray Silt Loam On Clay (1334.1)

Yellow-Gray Silt Loam On Clay occupies an area about a mile wide along each side of the two main tributaries of Saline river, and is found in smaller areas near Rector creek. The soil is of alluvial formation, slightly higher than the surrounding land, and not subject to such frequent overflow as Mixed Loam and Drab Clay Loam. Water never remains on this type for any length of time, and very seldom is there any deposit left. The land has been heavily covered with timber, chiefly oak, for many years. This type covers an area of 16.21 square miles.

The A_1 horizon, or surface soil, 0 to 4 inches, is a friable silt loam, brownish gray or yellowish brown as the type approaches Brown Silt Loam On Clay or Drab Clay Loam, and yellowish gray on the tops of the low ridges and near the stream channels. The A_2 horizon, or subsurface soil, 4 to 16 inches, is a slightly compact, yellowish gray clayey silt loam. The B horizon, or subsoil below 16 inches, is a very compact, plastic, yellow clay.

Management.—Yellow-Gray Silt Loam On Clay varies considerably in productive capacity depending on its topographic position. The flat areas have a more impervious subsoil than the undulating areas and are less productive. This type is strongly acid and is low in nitrogen and organic matter. Three

to four tons of limestone per acre should be applied, and clover grown at frequent intervals. After this has been done, trial should be made of one or more of the phosphates with particular reference to wheat, and it would also be well to try one of the potash salts for corn applied at the rate of about 100 pounds an acre.

Brown Silt Loam On Clay (1326.1)

Brown Silt Loam On Clay, when properly drained and cared for, is the most fertile land in the county. It is found chiefly along Rector creek in Plainview township (Township 7 South, Range 7 East). Smaller areas occur as slight knolls in the large areas of Drab Clay Loam. It covers 8.96 square miles.

The A_1 horizon, or surface soil, 0 to 8 inches, is a friable, grayish brown to black, heavy silt loam. The A_2 horizon, or subsurface soil, 8 to 16 inches, is a slightly compact, plastic, silty clay loam. The B horizon, or subsoil, 16 to 24 inches, is a compact, plastic, brownish yellow clay. The C horizon, or lower subsoil, below 24 inches, is a compact, plastic, yellow clay.

Management.—Brown Silt Loam On Clay usually is not acid, and is fairly well supplied with organic matter. Clover, as a source of nitrogen and fresh organic matter, should be grown at frequent intervals. If this is done, it is questionable whether any fertilizing materials can be used at the present time at a profit, excepting, of course, farm manure, which should always be carefully conserved and returned to the land.

RESIDUAL SOILS

Residual soils are confined entirely to the unglaciated region. They are of little agricultural value as they cannot be cropped with any success. Their topography is extremely rough and they can, no doubt, be most economically utilized by growing timber. Some areas may be used as pasture, and where limestone is the outcropping rock, it may serve as a source of material to sweeten sour or acid soil. This group of soils covers an area of 13.02 square miles.

Stony Loam (098)

Stony Loam occupies the steep slopes and gullies where erosion has removed most or all of the loess and residual soil material. The stones vary from a few inches to several feet in diameter and lie thick on the ground. This soil type comprizes 12.45 square miles. It is of little agricultural value, its only use, aside from the growing of timber, being for pasture.

Rock Outcrop (099)

Rock Outcrop is not considered a type of soil, for it is merely the exposure of rocks on the surface. These rocks occur most often as perpendicular ledges, the horizontal width of which is often exaggerated on the soil map in order to show the boundary lines. The outcrops are chiefly sandstone; limestone is exposed in deep ravines and at the base of bluffs but is always capped by sand stone. This limestone may be crushed, ground, and used to correct the acidity of sour soils.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order intelligently to interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items which may assist in the differentiation of types, but which are not fundamental to it, are native vegetation (whether timber or prairie), topography, and geological origin and formation.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a matured soil, three horizons designated as A, B, and C are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the A horizon.

C designates the layer lying below the B horizon and in which the material has been less affected by the weathering processes.

Frequently differences within these strata or zones are discernible, in which case they are subdivided and described under such designations as A_1 and A_2, B_1 and B_2, etc.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized as determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of four or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation

1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their

proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 7.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus,*

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

sulfur, potassium, calcium, magnesium, and *iron.* Other elements are absorbed from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5.

[2]Young second year's growth ready to plow under as green manure.

[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates,

nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive

in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4, have been found satisfactory. Some commercial firms are also offering similar preparations which are satisfactory.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, acid phosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of

the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average livestock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein.

When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the better adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover

seed being sold the fourth and sixth years); or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover.

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to Those Occurring in Saline County)

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated; (aP = acid phosphate, bP = bonemeal, rP = rock phosphate, sP = slag phosphate)
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
Le = Legumes used as green manure
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

THE RALEIGH FIELD

A University soil experiment field is located in Saline county immediately south of Raleigh. This field has been in operation since 1910. It comprizes 14 acres of light-colored, loessial soils characteristic of the region. The soil type indicated on the county map is Yellow-Gray Silt Loam. With accumulating experience in the soil survey, however, certain soil characteristics have come

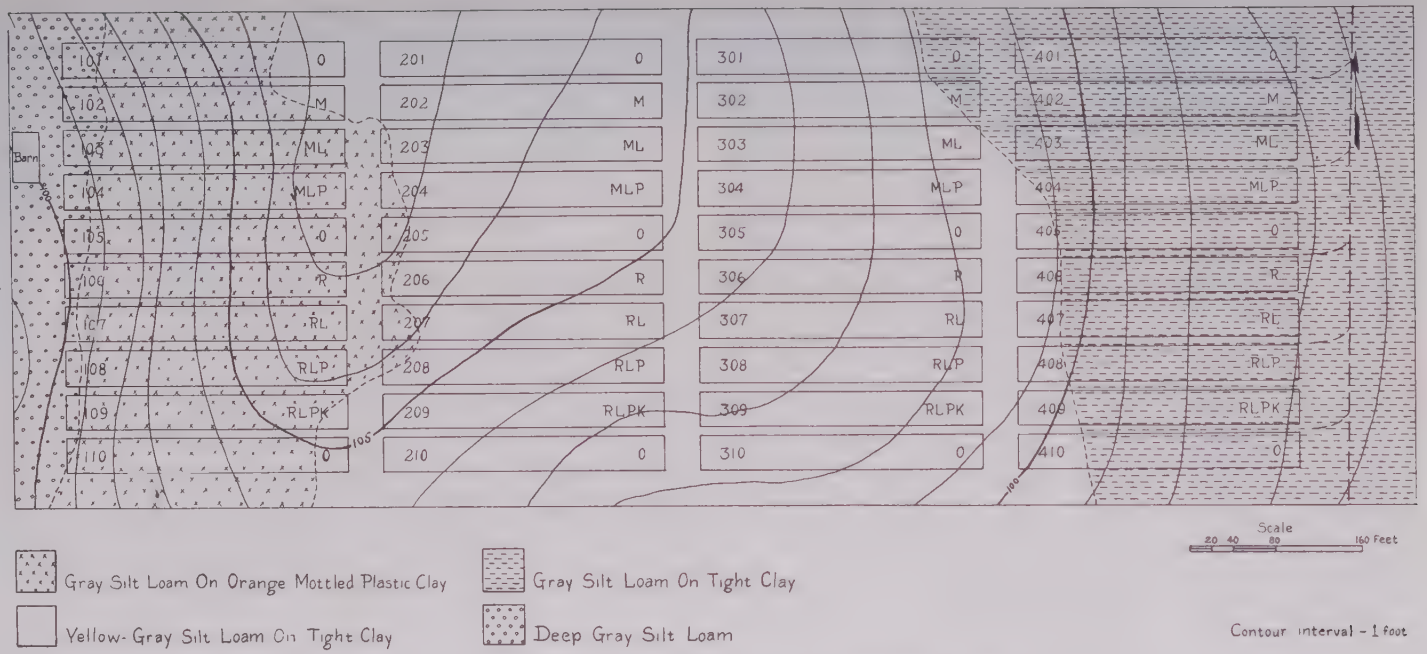


FIG. 2.—DIAGRAM OF THE RALEIGH SOIL EXPERIMENT FIELD

This diagram shows the arrangement of plots, the soil treatments applied, the location of the different soil types, and by means of contour lines, the natural drainage of this field.

TABLE 7.—RALEIGH FIELD: 1910–1923

Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1910 Wheat[1]	1911 Corn	1912 Oats	1913 Clover	1914 Wheat	1915 Corn	1916 Oats	1917 Soybeans	1918 Wheat	1919 Corn	1920 Oats	1921 Clover	1922 Wheat	1923 Corn
101	0	9.5	28.0	11.9	(.22)	11.8	21.4	10.8	(.76)	10.2	18.2	4.1	(.12)	8.0	23.9
102	M	6.9	41.0	15.2	(.23)	10.9	35.1	11.2	(.84)	14.6	29.4	3.9	(.52)	9.5	47.5
103	ML	9.8	45.8	23.4	(.72)	27.5	57.2	12.0	(1.25)	25.9	35.0	5.2	(1.69)	15.3	67.0
104	MLrP	11.6	46.7	22.7	(.68)	26.8	52.3	14.7	(1.57)	29.2	44.4	5.3	(2.03)	17.5	65.8
105	0	7.3	24.9	14.1	.02	9.4	21.8	10.9	3.5	11.8	13.4	2.8	(.18)	6.3	27.1
106	R	9.0	24.4	12.8	.02	9.2	24.4	11.4	5.7	12.8	17.5	3.0	(.28)	9.9	31.2
107	RL	11.0	36.8	20.9	.08	25.1	43.5	10.6	10.4	22.2	40.0	8.0	(1.45)	20.6	53.9
108	RLrP	10.7	31.1	23.0	.01	27.2	42.0	14.7	12.9	27.2	48.0	7.7	(1.85)	18.5	59.7
109	RLrPK	12.7	39.5	25.8	.03	30.0	47.2	16.7	9.4	24.9	50.1	7.9	(1.92)	29.6	68.2
110	0	5.7	17.8	8.1	.01	7.2	22.3	9.2	(.67)	10.7	17.0	1.7	(.07)	4.5	22.8
		Cowpeas[1]	Wheat[2]	Corn	Oats	Soybeans	Wheat[4]	Corn	Oats	Clover	Wheat	Corn	Oats	Soybeans	Wheat
201	0	(.86)	12.1	20.5	.6	(.28)	....	22.9	17.5	(.26)	5.8	11.4	8.3	3.4	.0
202	M	(..75)	12.7	36.5	2.0	(.30)	....	34.9	23.3	(.12)	10.9	26.4	7.3	4.3	.3
203	ML	(1.38)	17.5	55.1	3.1	(.26)	....	45.0	36.1	(.86)	23.5	56.9	15.8	8.7	2.9
204	MLrP	(1.35)	19.0	53.9	3.0	(.23)	....	43.2	36.7	(1.01)	24.1	60.7	15.2	9.3	3.9
205	0	(.74)	9.5	20.4	1.7	(.27)	....	23.6	20.3	.00	9.3	15.2	6.9	5.5	.0
206	R	....[3]	12.3	29.9	2.0	2.5	....	24.7	25.9	.00	12.6	22.6	12.7	5.7	.0
207	RL	....[3]	19.9	45.2	4.4	2.5	....	40.1	42.0	.21	21.7	42.8	17.8	11.1	2.0
208	RLrP	....[3]	22.7	55.1	5.2	2.7	....	45.6	44.8	.25	24.7	44.8	19.8	14.2	2.2
209	RLrPK	....[3]	22.8	56.5	7.2	1.8	....	46.8	47.7	.33	26.3	59.7	17.7	18.3	3.9
210	0	(1.09)	14.7	25.2	2.7	.7	....	30.0	30.2	(.12)	14.2	23.9	7.3	8.5	.2

TABLE 7.—RALEIGH FIELD, *Concluded*

Plot No.	Soil treatment applied	1910 Oats[1]	1911 Clover[2]	1912 Wheat[2]	1913 Corn	1914 Oats	1915 Soybeans	1916 Wheat	1917 Corn	1918 Oats	1919 Soybeans	1920 Oats[6]	1921 Corn	1922 Oats	1923 Soybeans
301	0	18.1	(.44)	3.4	5.7	2.5	1.1	.8	24.4	26.2	(.24)	11.9	.6	2.2	6.9
302	M	17.3	(.43)	2.3	12.9	5.0	(1.81)	1.8	44.7	35.6	(.28)	15.5	6.3	2.8	11.0
303	ML	26.8	(.61)	7.1	17.2	8.1	(2.16)	7.8	57.5	47.5	(.64)	20.0	20.0	10.9	21.2
304	MLrP	26.0	(.68)	7.8	17.1	7.8	(2.30)	9.8	58.9	47.3	(.86)	18.6	28.6	10.8	23.6
305	0	15.0	(.23)	2.0	4.5	2.0	1.0	.2	25.7	24.1	2.2	10.0	7.3	1.1	9.2
306	R	20.9	....[3]	2.8	9.4	4.1	.8	.7	19.9	31.6	2.8	12.2	12.6	1.9	12.7
307	RL	25.1	....[3]	7.4	17.5	9.5	3.4	6.7	45.1	55.9	6.7	18.0	28.5	11.4	20.3
308	RLrP	25.1	....[3]	9.9	17.9	11.2	3.9	7.7	41.1	56.1	7.8	18.6	39.3	13.8	21.8
309	RLrPK	29.3	....[3]	14.1	15.9	10.3	3.9	6.6	63.4	55.2	9.1	18.9	50.9	12.2	24.1
310	0	22.9	....[3]	4.7	7.4	5.0	.4	1.8	35.1	29.8	(.47)	13.4	26.4	3.0	13.6
		Corn[1]	Oats[2]	Cowpeas[2]	Wheat[2]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats
401	0	24.1	25.6	(1.44)	6.2	7.6	9.7	(.56)	6.3	13.2	9.2	(.00)	8.2	18.9	9.5
402	M	18.1	19.2	(1.05)	4.2	13.2	8.9	(.89)	7.8	22.9	9.1	(.00)	9.2	35.8	14.1
403	ML	40.1	38.0	(2.79)	20.7	16.3	23.6	(1.44)	41.2	22.9	20.8	(1.28)	25.8	66.6	28.0
404	MLrP	37.4	35.5	(2.56)	23.8	14.1	24.7	(1.98)	39.2	20.4	21.9	(1.60)	28.2	67.5	31.9
405	0	24.9	18.4	(.93)	6.4	8.5	9.8	....[5]	11.2	14.9	7.5	(.00)	9.2	23.2	12.8
406	R	31.1	24.1	....[3]	8.5	10.7	12.8	....[5]	15.2	17.8	11.9	(.00)	11.2	27.1	11.7
407	RL	42.8	38.6	....[3]	29.8	14.4	23.1	....[5]	37.2	23.8	22.8	(1.60)	25.3	46.5	29.5
408	RLrP	44.5	35.3	....[3]	32.9	16.4	22.5	....[5]	40.5	22.8	22.8	(1.61)	29.2	48.8	30.8
409	RLrPK	43.0	32.8	....[3]	29.8	16.4	20.8	....[5]	46.4	23.7	25.0	(1.79)	32.5	57.2	30.6
410	0	26.8	25.0	(1.14)	4.7	4.6	7.5	(.83)	5.3	12.8	8.6	(.00)	9.0	20.6	13.4

[1]No manure or residues. [2]No manure. [3]No seed harvested. [4]Crop destroyed by hail. [5]Seed lost before recleaning. [6]Substitute for wheat.

to attention which formerly were not recognized and which, in some instances, call for modifying the classification shown by the county soil map. Thus a more detailed examination has revealed the presence of what now may be regarded as four distinguishable soil types on the Raleigh field; namely, Yellow-Gray Silt Loam On Tight Clay, Gray Silt Loam On Tight Clay, Gray Silt Loam On Orange-Mottled Plastic Clay, and Deep Gray Silt Loam. The distribution of these soil types as well as the arrangement of plots is charted on the accompanying diagram (Fig. 2). The topography, or lay of the land, is indicated on the diagram by contour lines. The land has been tiled and the drainage is good.

The field is laid out into four series of 10 plots each. Fortunately the plot series run fairly parallel with the soil types in such manner that the 100 Series is located mainly on Gray Silt Loam On Tight Clay, the 200 and 300 Series are almost entirely confined to Yellow-Gray Silt Loam On Tight Clay, and the 400 Series lies mainly on Gray Silt Loam On Orange-Mottled Plastic Clay. The plots are under a four-crop rotation system of wheat, corn, oats, and clover. In the event of clover failure either soybeans or cowpeas have been substituted as the legume crop. The soil treatments are as indicated in the accompanying diagram and tables, and until 1922 they were applied in the manner described above. In 1922 the return of the wheat straw in the residue system was discontinued. In the same year the regular application of limestone was suspended until such time as it appears to be needed again. In 1923 the rock phosphate was evened up on all phosphate plots to a total application of 4¼ tons an acre, and the applications were discontinued for an indefinite period.

At this time the plots were divided into west and east halves for the purpose of instituting some new investigations designed to help solve some of the problems that have arisen during the course of the experiments. The west halves were continued under their original treatments, while the east halves were given over to a study of the phosphate question. The particular treatments on the divided plots are shown in Table 8.

The yields of all the crops grown since the beginning of the experiments are placed on record in Tables 7 and 8. For convenience in studying the effects of the treatments, the results are summarized and presented in Table 9, which shows the average annual yields for the several kinds of crops, including the years since the complete plot treatments have been in effect. This summary includes all of the results of Table 7, together with those in Table 8, which pertain to the west half-plots.

A study of these data brings out the following comments concerning the effects of the various treatments on the Raleigh field:

1. The untreated plots are conspicuous in their low yields.
2. All the different kinds of crops show some response to the application of stable manure, altho the beneficial effect varies greatly.
3. Crop residues used alone have been of very little effect.
4. Limestone stands out in its effect as the most prominent agency in soil improvement.
5. The combination of residues and limestone has produced yields almost as high as that of manure and limestone.

FIG. 3.—CORN ON THE RALEIGH FIELD

At the right no treatment has been applied; at the left, manure, limestone, and phosphate have been applied, the major effect being produced by the limestone and manure.

FIG. 4.—CORN ON THE RALEIGH FIELD

The treatment here is the same as that shown in Fig. 3 except that no manure is used, the organic matter being supplied by crop residues, including stalks, straw, and legumes plowed under.

TABLE 8.—RALEIGH FIELD: 1924–1925
Annual Crop Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment	1924				1925			
		Series 100 Oats	Series 200 Corn	Series 300 Wheat	Series 400 Clover	Series 100 Timothy-clover	Series 200 Oats	Series 300 Corn	Series 400 Wheat
1 W	0	16.6	1.2	.3	(0.00)	(0.00)	12.8	17.4	1.8
1 E	RL	18.8	1.4	1.2	(0.00)	(0.00)	17.5	22.0	6.3
2 W	M	32.8	7.8	3.2	(0.00)	(.44)	25.9	29.0	7.3
2 E	MrP	35.6	.6	7.5	(0.00)	(.29)	35.9	31.6	10.5
3 W	ML	50.3	33.2	10.7	(1.31)	(2.24)	44.7	33.2	25.5
3 E	MLbP	50.6	26.8	13.5	(1.64)	(1.80)	46.9	44.0	33.7
4 W	MLrP[1]	57.5	34.4	15.8	(1.42)	(2.37)	46.9	37.0	26.7
4 E	MLrP	50.9	27.6	17.3	(1.78)	(2.09)	49.7	44.8	34.3
5 W	0	29.1	2.2	0.0	(0.00)	(.41)	17.5	11.8	3.5
5 E	RaP	28.1	.1	5.3	(0.00)	(0.00)	27.8	16.2	13.8
6 W	R	29.1	6.0	1.2	(0.00)	(.32)	22.5	20.0	5.8
6 E	RrP	26.6	2.0	6.3	(0.00)	(0.00)	34.7	24.2	17.7
7 W	RL	47.8	33.0	7.3	(1.41)	(1.00)	32.2	37.2	22.0
7 E	RLaP	54.1	38.2	14.0	(.28)	(.99)	43.8	38.6	28.5
8 W	RLrP[1]	58.1	32.2	9.2	(.57)	(1.68)	43.0	54.0	26.7
8 E	RLrP	50.3	45.6	11.2	(.87)	(1.37)	45.9	54.2	31.8
9 W	RLrP[1]K	57.2	41.4	14.0	(1.25)	(1.98)	42.5	52.8	28.2
9 E	RLrP[1]K-Gypsum	50.9	45.2	18.3	(1.47)	(1.70)	48.8	60.4	34.7
10 W	0	16.6	2.6	1.5	(0.00)	(0.00)	15.6	24.4	9.2
10 E	RLrP	17.5	13.2	4.2	(0.00)	(0.00)	44.7	46.8	12.7

[1]Residual phosphate.

6. A very small crop increase in every case has attended the application of phosphate, but this increase is not sufficient to cover the cost of the rock phosphate used. As mentioned above, the phosphate problem is now being

TABLE 9.—RALEIGH FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1911-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *15 crops*	Oats *15 crops*	Wheat *10 crops*	Clover[1] *7 crops*	Soybeans[1] *6 crops*
1	0	15.7	10.3	5.3	(.17)	(.61)
2	M	28.2	14.2	7.6	(.31)	(.80)
3	ML	41.9	23.3	20.6	(1.36)	(1.22)
4	MLrP	43.0	24.3	22.1	(1.58)	(1.38)
5	0	16.3	11.4	6.1	(.10)	(.40)
6	R	19.9	13.7	7.9	(.10)	(.50)
7	RL	36.6	23.6	19.0	(.96)	(.91)
8	RLrP	39.9	25.9	21.3	(1.00)	(1.06)
9	RLrPK	46.0	26.4	24.2	(1.22)	(1.11)
10	0	19.5	11.5	6.4	(.15)	(.65)

[1]Including several seed crops evaluated in this summary as hay.

made the subject of special investigation on these plots. The residual effect of phosphate previously applied, on the one hand, and new applications under different methods, on the other hand, should furnish in the next few years much more definite information regarding the economical use of phosphate than now exists.

7. Potassium in the form of kainit has likewise increased the yield of all crops, particularly the corn, wheat, and clover. At current prices the value of the increase is just about offset by the cost of the kainit applied.

FIG. 5.—A PARTY LOOKING OVER DEMONSTRATIONS IN SOIL MANAGEMENT ON THE RALEIGH EXPERIMENT FIELD

Regarding the cropping system employed on this field, it may be said that altho it serves fairly well for experimental purposes in determining the needs of the soil, for farming practice it doubtless could be improved, either by substituting a more profitable crop for the oats, or by rearranging the crop sequence and omitting the oats.

THE SPARTA FIELD

As representative of experimental results on the soil type Light Gray Silt Loam On Tight Clay, data from certain plots on the Sparta experiment field are introduced here. The Sparta field was established in Randolph county immediately north of the town of Sparta in 1916. The four series of plots designated as the 100, 200, 300, and 400 Series, with the exception of parts of two plots, are all on the soil type mapped as Light Gray Silt Loam On Tight Clay. They are under a crop rotation of corn, soybeans, wheat, and clover (chiefly sweet clover). Until 1921 is was the practice to seed cowpeas as a cover crop in the corn on the residues plots. The soil treatments are as indicated in the accompanying table, and they have been applied in the manner previously described, with the exception that the initial application of limestone was 5 tons an acre and in 1922 the periodic application of this material was discontinued until its further need should become apparent.

Table 10 gives a summary of the results showing the average annual yields for the different kinds of crops, including the years that the complete soil treatments have been in effect.

The low yields on the untreated plots testify to the natural poverty of this soil, altho this particular piece of land, on account of its favorable location with

TABLE 10.—SPARTA FIELD: SERIES 100, 200, 300, AND 400

SUMMARY OF CROP YIELDS

Average Annual Yields 1917-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *9 crops*	Soybeans[1] *8 crops*	Wheat *7 crops*	Clover *1 crop*	Sweet clover seed *5 crops*
1	0	15.6	(.62)	5.4	(0.00)	0.00
2	M	19.4	(.80)	7.8	(0.00)	0.00
3	ML	29.8	(1.47)	17.1	(1.66)	1.60
4	MLrP	30.8	(1.47)	17.7	(1.73)	1.38
5	0	13.4	(.52)	5.5	(0.00)	0.00
6	R	16.3	(.61)	5.5	(0.00)	0.00
7	RL	23.3	(1.28)	16.2	(1.50)	1.17
8	RLrP	23.4	(1.38)	17.1	(1.87)	1.41
9	RLrPK	29.2	(1.40)	18.3	(1.69)	1.86
10	0	11.4	(.59)	4.6	(0.00)	0.00

[1]Including several seed crops evaluated in this summary as hay.

respect to drainage, is rather more productive than the general run of the type that it represents.

Neither manure nor residues, used alone, has much effect toward crop improvement. A sharp increase, however, follows the application of limestone used with either manure or residues. Without limestone, clover refuses to grow; with limestone, fair crops of clover have been obtained. Rock phosphate in addition to limestone has produced no significant effect, used either with manure or with residues.

Potassium seems to have been of some benefit to the corn but not to the other crops. It is questionable, however, whether the increase in corn yield would cover the cost of material as it was used in these experiments. It is possible that smaller quantities applied direct to the corn crop would prove a more economical way to use potassium fertilizer on this soil.

THE ELIZABETHTOWN FIELD

The Elizabethtown experiment field was established by the University in 1917, in the unglaciated hilly section of southern Illinois. This field is located in Hardin county about two miles north of Elizabethtown. The soil is of loessial formation, the predominating type on this field being classified as Yellow Silt Loam. A detailed examination, however, shows the presence of some Yellow-Gray Silt Loam and also a very small patch of Stony Loam. The land is extremely rough in topography, the contour map showing a range in elevation of 42 feet on that part of the field occupied by the present plots. Erosion, therefore, is a serious problem. The field embraces about 32 acres, of which area about one-half is laid off into plots. There are four series of 10 fifth-acre plots each, included in a major rotation. Another series of 10 tenth-acre plots is devoted to another rotation, and in addition to these there are three other plots designated as A, B, and C, upon which a special phosphate test is being carried on.

The major rotation formerly included corn (with rye cover crop), soybeans, wheat, and sweet clover, but this was changed in 1923 to a rotation of corn, wheat, clover-timothy mixture, and wheat with sweet clover seeding on the residue plots. The plot treatments are indicated in the following table of

TABLE 11.—ELIZABETHTOWN FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1919-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *7 crops*	Wheat following legume *5 crops*	Wheat following corn *3 crops*	Timothy-clover mixture *3 crops*	Soybeans *3 crops*	Sweet clover seed *2 crops*
1	0	18.6	7.8	4.9	(.12)	2.7	0.00
2	M	18.3	6.2	4.6	(.10)	3.1	0.00
3	ML	33.3	14.0	9.3	(.94)	4.2	2.59
4	MLrP	40.6	18.2	9.7	(1.37)	5.2	2.42
5	0	12.9	5.8	2.0	(.07)	2.3	0.00
6	R	15.9	5.1	2.3	(.09)	2.5	0.00
7	RL	34.8	12.2	5.7	(.94)	4.3	1.99
8	RLrP	45.2	17.6	8.1	(1.37)	5.0	1.74
9	RLrPK	44.8	19.3	8.3	(1.65)	4.6	1.49
10	0	23.6	7.7	4.8	(.05)	3.0	0.00

results. The difficulty of obtaining satisfactory experimental data on land of such rough topography is obvious. There are, however, certain effects standing out in such bold relief as to leave no doubt as to their significance. The results for the different crops are summarized in Table 11.

These results show extremely poor yields on the untreated land, with no improvement from the use of manure alone or residues alone. A sharp increase in yield, however, follows the application of limestone along with either manure or residues. Rock phosphate seems to have produced a beneficial effect on the corn, on the wheat following legumes, and on the timothy-clover mixture, in both the manure and the residues systems. The potassium treatment as applied in these experiments does not show sufficient benefit to cover the cost. The following general observations are of interest. The wheat following legumes has a much more favorable place in the rotation than the wheat following corn, which fact is manifested by the relative yields. Soybeans have not proved a very successful crop on this field. It is of interest to note that the residues system appears to be fully as effective in building up this soil as the manure system, but a rational system of farming might well include livestock, in which the manure as well as all available crop residues would be utilized for soil improvement.

The results from the minor rotation on Series 500 are too few to warrant consideration at this time.

On Plots A, B, and C a comparison of the two carriers of phosphates, acid phosphate and rock phosphate, is under way. The acid phosphate is applied at the rate of 200 pounds an acre a year and the rock phosphate in double this quantity. The plots also receive residues and limestone.

In a rotation of corn, cowpeas, and wheat, four crops of corn, three of cowpeas, and three of wheat can be compared at this time. It is of interest to note the results that thus far have been obtained, bearing in mind that the data are not sufficient to warrant drawing final conclusions as to which carrier of phosphorus will prove to be the more economical to use. Table 12 presents the crop yields from these comparative phosphate tests covering the period since the full soil treatment has been applied.

TABLE 12.—ELIZABETHTOWN FIELD: COMPARATIVE TEST OF ACID PHOSPHATE AND ROCK PHOSPHATE

Annual Yields of Crops Grown, 1921-1925—Bushels or (tons) per acre

Year	Corn		Wheat		Cowpeas	
	Acid phosphate	Rock phosphate	Acid phosphate	Rock phosphate	Acid phosphate	Rock phosphate
1921	28.8	28.6	....	....	9.2	7.8
1922	34.4	32.0	3.2	9.8	12.5	4.7
1923	32.2	46.8	18.6	14.3	10.5	9.2
1924	54.6	59.2	13.3	8.8	(.78)	(.80)
1925	60.2	62.0	8.5	10.0	(1.66)	(1.27)
Average	42.0	45.7	12.4	11.9	Seed 10.7 Hay (1.22)	7.2 (1.04)

On the whole, the differences shown in the averages are relatively small, so that it may be said that after four years the data furnish no reliable indication as to which form of phosphate is the more effective in increasing crop yields.

THE OLD VIENNA FIELD

From 1902 to 1911 the University conducted an experiment field in Johnson county, about two miles southeast of Vienna, on land that was described at the time as "red clay, a soil typical of the hill sections of the state." The soil is characteristic of much of the type designated as Yellow Silt Loam. The field comprized a tract of 5.6 acres of land rolling in topography, a portion of which was low and wet. It was not tile-drained.

Previous to 1902 this land had been cultivated for about fifty years, after which it was said to be still capable of producing fair crops of corn and wheat.

For the experiment work the field was laid out into three series of plots one-fifth acre in size, each series containing 5 plots. A crop rotation of wheat, corn, and cowpeas was started; but in 1905 this rotation was changed to corn, oats, wheat, and legumes. Cowpeas for plowing down were seeded in the corn at the last cultivation excepting on Plot 1. As the carrier of phosphorus, steamed

TABLE 13.—OLD VIENNA FIELD: SUMMARY OF GRAIN CROPS

Average Annual Yields 1903-1911—Bushels per acre

Soil treatment	Corn *9 crops*	Wheat *8 crops*
0	29.0	3.0
Le	29.8	5.7
LeL	39.7	10.9
LeLP	37.5	13.6
LeLPK	40.7	15.6

bone meal was used at the rate of 200 pounds an acre a year. Potassium was applied in the form of potassium sulfate, this material being used at the annual acre rate of 100 pounds. Lime was applied in 1902 in the form of slaked lime at the rate of 1,800 pounds, and the following year limestone was added at the rate of 8 tons an acre.

Table 13 presents a summary giving the average annual acre yields of the 9 corn crops and 8 wheat crops harvested after the plots had received their respective treatments.

The great need of this land for organic matter and nitrogen is brought out in these results. Organic matter and nitrogen are furnished by the legumes in these experiments; but in order to produce a thrifty growth of legumes, it was necessary to apply lime. Thus, upon the addition of limestone, the corn yield was increased by one-third, while the wheat yield was practically doubled. In the case of the corn, little or no effect was produced by the addition of either phosphorus or potassium treatment. In the wheat, however, an increase of about 3 bushels an acre a year appears upon the addition of phosphorus, and a further increase of 2 bushels an acre a year upon including potassium in the treatment.

The yields from the three clover crops are not summarized here but it may be stated that some very fair yields of clover were obtained on the better treated plots.

Altho these results furnish an indication of the most important needs of this land, it cannot be said that the experiments as conducted represent directly an economical system of farming. Considering the several years in which the land was given over to the growth of a green manure crop when nothing was harvested, even the yields from the best plots would scarcely be sufficient to cover the cost of maintenance. However, it appears possible that by modifying the cropping plan in some manner, as for example, substituting sweet clover for cowpeas and giving large place in the farming system to hay and pasture crops, production might be substantially increased and thus a system of farming instituted that would represent a profitable enterprise.

THE NEW VIENNA FIELD

From 1906 to 1924 another experiment field, designated as the new Vienna field, was maintained. This field was located about a mile southeast of Vienna and about a half-mile west of the old Vienna field described above. It embraced 16 acres of the badly eroded, hilly land characteristic of the region.

The soil of this field is, in general, of loessial formation. It is strongly acid in reaction. A detailed examination of the area occupied by the field reveals three separable types, namely, Yellow Silt Loam, Yellow-Gray Silt Loam, and Deep Gray Silt Loam.

The work on this field from 1906 to 1915 was concerned with an investigation of methods of reclaiming this land primarily thru means of reducing erosion. Before taking over the field, the land, with the exception of about three acres, had been abandoned because so much of the surface soil had been washed away, and gulleying had become so bad that further cultivation was unprofitable. Some of the gulleys were four or five feet deep, so that the first step in reclaiming the land was to fill them and thus make the slopes more uniform.

The field was divided into five sections. The sections designated as A, B, and C were divided into 4 plots each, and D into 3 plots. On Section A, which included the steepest part of the area and contained many gullies, the land was

FIG. 6.—THIS UNIMPROVED HILLSIDE OCCURS OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 7

built up into terraces at vertical intervals of five feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

On Section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges sufficiently high so that if the water breaks over, it will run over in a broad sheet rather than in rills thru narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about eight loads of manure an acre were turned under each year for the corn crop.

The land on Section D was washed to about the same extent as that of section C. As a check on the different methods of reducing erosion, the land on Section D was farmed in the most convenient way, without any special effort being made to prevent washing.

TABLE 14.—NEW VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

FIG. 7.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD. THIS LAND FORMERLY HAD BEEN ERODED (Compare with Fig. 6)

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

Sections A, B, C, and D were not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section excepting D which had but three plots.

Table 14 contains a summarized statement of the results obtained. For a more detailed account of this work the reader is referred to Bulletin 207 of this Station entitled "Washing of Soils and Methods of Prevention."

These results indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels for Series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 6 and 7 will serve to indicate the possibility of improving this type of soil.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1925
33 Saline, 1926

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 34

MARION COUNTY SOILS

By R. S. SMITH, E. A. NORTON, E. E. DeTURK, F. C. BAUER, AND L. H. SMITH

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URBANA, ILLINOIS, NOVEMBER, 1926

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form on an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Marion county was conducted, and to Mr. H. C. Wheeler, who was in direct charge of the field party in the construction of the map.

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MARION COUNTY SOILS

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MARION COUNTY SOILS

By R. S. SMITH, E. A. NORTON, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

LOCATION AND CLIMATE OF MARION COUNTY

Marion county is located in the central southern part of Illinois, near the center of that area commonly referred to as "Egypt." The county is square in shape, is of medium size, and contains 565 square miles. It lies entirely within the geological area now thought by geologists to be of pre-Illinoisan age.

The climate of Marion county is characterized by a wide range between the extremes of winter and summer and by an abundant, fairly well-distributed rainfall with the exception that the months of July and August are likely to be drouthy. In some years the rainfall during these months is excessive and comes in the form of thunder showers which beat the ground and are otherwise harmful. The average annual rainfall during the past thirty years, as computed from Weather Bureau stations in the vicinity of Marion county, has been 40.34 inches. The average rainfall by months for this period has been as follows: January, 3.03 inches; February, 2.63; March, 3.24; April, 3.85; May, 3.98; June, 4.19; July, 3.39; August, 3.57; September, 3.66; October, 3.02; November, 2.95; December, 2.83.

The greatest range in temperature for any one year during the past thirty years, also computed from Weather Bureau stations in the vicinity of this county, was 126 degrees in 1899. The lowest temperature recorded was 22° below zero in February, 1899; the highest, 113° in July, 1901. The average date of the last killing frost in the spring is April 14; the earliest in the fall, October 16. The average length of the growing season is 185 days.

AGRICULTURAL PRODUCTION

Marion county is distinctly agricultural; there is no large industry of importance in the county other than that of farming. Farming, however, is tending toward specialized crops, because of certain soil characteristics and the influence of climate. According to the Fourteenth Census of the United States, there were 3,097 farms in Marion county in 1919, the average size of farm being 106.8 acres, 90.7 of which were improved. Of these 3,097 farms, 22.8 percent were operated by tenants in 1919. The number of farms has decreased slightly in the past twenty years, and there has been also a slight decrease in tenantry corresponding to the decrease in farms over the same period.

The principal crops grown in this county are fruits, hay, corn, wheat, and oats. The following tables show the acreage and yield of the more important field crops for the year of 1919, as given by the above-mentioned Census.

---

[1] R. S. Smith, in charge of soil survey mapping; E. A. Norton, associate in soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	32,052	285,994 bu.	8.9 bu.
Wheat	30,638	371,056 bu.	12.1 bu.
Oats	33,059	578,532 bu.	17.5 bu.
Rye	2,987	25,713 bu.	8.6 bu.
Timothy	13,403	11,522 tons	.86 ton
Timothy and clover mixed	2,546	2,779 tons	1.09 tons
Clover	346	415 tons	1.20 tons
Redtop	32,184	22,803 tons	.71 ton
Silage crops	819	3,250 tons	3.96 tons
Corn for forage	10,473	11,461 tons	1.09 tons

In considering these figures it should be borne in mind that they represent the yields of a single year only, those of 1919, which appears to have been an exceedingly poor year for corn. Figures furnished by the U. S. Department of Agriculture give the following average acre yields for the ten-year period 1911-1920: corn, 18.3 bushels; wheat, 12.8 bushels; oats, 18.6 bushels; tame hay, .93 ton. Leguminous crops such as cowpeas and sweet clover have been given considerable attention during the past five years.

Fruits, particularly apples, peaches, and strawberries, have been fairly remunerative in the past and give promise to be more so in the future. The following figures show the production in Marion county for the last Census year:

Tree Fruits	*Production*	*Small Fruits*	*Production*
Apples	170,138 bu.	Strawberries	351,938 qts.
Peaches	27,800 bu.	Raspberries	4,793 qts.
Pears	26,519 bu.	Blackberries and dewberries	30,410 qts.
Cherries	390 bu.	Grapes	48,248 lbs.

Marion county is not an important livestock county. The total value of all livestock and livestock products in 1919 was $3,730,776. The following figures from the 1920 Census show the character of the livestock interests:

Animals and Animal Products	*Number*	*Value*
Horses	11,401	$750,981
Mules	1,847	157,920
Beef cattle	5,340	250,497
Dairy cattle	16,078	875,979
Sheep	7,837	89,778
Swine	13,488	156,939
Eggs and chickens	.....	562,010
Dairy products	.....	477,289

SOIL FORMATION

GEOLOGICAL HISTORY

Previous to the Glacial period the country thruout the state of Illinois was generally rough, having been cut by numerous streams into hilly topography. During the Glacial period snow and ice accumulated in the region of Labrador and to the west of Hudson Bay in such large amounts that the mass pushed outward from these centers, chiefly southward. In moving across the country from the north, the ice gathered up all sorts and sizes of materials including clay, silt, sand, gravel, boulders, and even immense masses of rock. Some of these materials were carried several hundred miles as the ice pushed forward, and an immense amount of rock powder was produced by the grinding or file-like action of the rock material imbedded in the ice.

During this period at least six distinct ice advances occurred that were separated by long periods of time. They are listed as follows, in the order of their occurrence: the Nebraskan, the Kansan, the Illinoisan, the Iowan, the early Wisconsin, and the late Wisconsin. While geologists have accurately traced the limits of advance of the later glaciations, the exact area covered by the earlier ones is difficult to determine because of the effect of subsequent glaciations.

The material transported by the glaciers varied with the character of the rocks over which they passed. Granites, sandstones, limestones, shales, etc., were torn from their lodging places by the enormous denuding power of the ice sheet and ground up together, thus forming an immense amount of fine sediment. A pressure of 40 pounds a square inch is exerted by a mass of ice 100 feet thick, and these ice sheets were hundreds, or possibly thousands, of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which they passed. Preglacial ridges and hills were rubbed down, valleys were filled with debris, and the surface features entirely changed. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

A glacial advance prior to the Illinoisan extended over most of the state and covered Marion county. Many of the preglacial ridges or valleys were rubbed down or covered up with drift by this ice sheet, so that all surface indications of preglacial topography have been completely obliterated. The upland in the northern part of the county was covered to an average depth of 18 to 25 feet, the deposit being more shallow to the south. Along the southern border of the county the drift is about 12 feet deep, and on the ridges it is rarely over 10 feet and often no more than 5 feet. The old valleys were filled to depths of 40 to 100 feet. The comparatively level surface thruout Marion county is the result of glacial denudation and deposition.

It should be understood that the glacial drift itself makes up only part of the actual soil material in this county, for after the Glacial period this region was partially covered by a stratum of wind-blown, silty material known as loess. This wind-blown material was the rock flour produced by the grinding action of the glacier which was carried out and deposited in the flood plains and river bottoms during the time the glacier was melting and receding. There it dried, was picked up by the wind, and carried over the upland as dust. It was sorted and re-sorted by the wind, the coarser materials being deposited near the source and the finer or lighter material being carried many miles. Marion county received only a shallow deposit of this silty loess because it was some distance from any main drainage outlet. The loessial deposit probably varies from a few inches on the east side of the county to a few feet on the west.

The glacial drift which has been exposed on or near the surface during the long interval of time which has elapsed since its deposition has weathered into finely divided particles with only an occasional pebble, chiefly chert, remaining. It is very difficult, and perhaps impossible, to distinguish between this thoroly weathered drift and loess. In all probability this decomposed glacial material has become mixed with the wind-blown, silty loess, giving the county a loess-like

covering varying from 20 inches in the eastern part to about 4 feet in the western part. On the steep slopes, where erosion has removed some or all of this loess-like material, the sandy, pebbly drift is exposed and forms the soil material.

SOIL DEVELOPMENT

Glacial till and silty loess, principally a mixture of the two, are the soil materials from which the soils of Marion county have been derived. The agencies of weathering acted upon these deposits causing the leaching of certain minerals, the accumulation of others, and the movement of particles into layers, zones, or horizons. This, with the addition of organic matter from the decay of roots and other plant growth, formed the soil.

The soil was probably much darker in color and much more productive in the earlier periods of its existence than at present. As time went on two important changes occurred in the soil which served to reduce its productivity. Shrubs and trees appeared near the stream channels and in well-drained areas, and forests gradually spread over the prairies. In upland forests the residues consist mainly of fallen leaves, branches, and dead trees, which become almost completely destroyed either by burning or by exposure to the oxygen of the air and to fungi. The second important change which took place in the soil was the concentration of the smaller soil particles, thru the downward movement of soil water, into a restricted zone, known as the B horizon, until their accumulation impaired underdrainage. The impervious layer or "tight clay" thus formed has been commonly, tho erroneously, called "hardpan." This condition caused the soil to become water-logged in the rainy seasons, and extremely dry during summer and fall, thus retarding the accumulation of organic matter. The soils of Marion county are characterized by a strongly developed B horizon, or accumulative zone.

PHYSIOGRAPHY AND DRAINAGE

Marion county is one of the most level counties in the state. It does not have extremes in topography; in fact, there is less than 150 feet of difference in the altitude of the highest and lowest points in the county. The altitudes of some of the places are as follows: Centralia 500 feet above sea level; Fairman, 530; Kell, 607; Kinmundy, 609; Patoka, 512; Odin, 529; Salem, 546; Sandoval, 490; Vernon, 525. There are three areas in the county, each covering 10 to 20 square miles, which have rolling topography; one, in the southwest part of Kinmundy township (Township 4 North, Range 3 East); the second, the east half of Haines township (Township 1 North, Range 3 East); and the third, the southern part of Centralia township (Township 1 North, Range 1 East). The remainder of the county is flat to undulating, except for a few preglacial knolls which rise from 15 to 60 feet above the surrounding country, and for slopes caused by recent stream erosion along the main drainage outlets.

Marion county lies within two well-defined drainage basins, the Kaskaskia and Little Wabash rivers (see drainage map, Fig. 1). About 60 percent of the county is drained by the Kaskaskia system. The dividing line between it and the Little Wabash system lies in a north-south direction about three miles east of the center of the county, the line bending toward the northeast as it approaches

LEGE

(a) UPLAND PRAIRIE SOILS

330 Gray silt loam on tight clay

328 Brown-gray silt loam on tight clay

329 Drab silt loam

(b) UPLAND TIMBER SOILS

34 334 Yellow-gray silt loam

35 335 Yellow silt loam

332 Light gray silt loam on tight clay

(c) R

233

234

000 Residual

200 Ridge Soils

300 Lower Illinoisan Glaciation

Scale

0 ¾ ½ 1 2Miles

SOIL SURVEY MAP

UNIVERSITY OF ILLINOIS AGRICU

SOILS

d silt loam on tight clay

-gray silt loam

(d) RESIDUAL SOILS

099 Rock outcrop (sandstone)

Small areas rock outcrop

(e) 1300 OLD SWAMP AND BOTTOM-LAND SOILS

1331 Deep gray silt loam

1354 Mixed loam

1321 Drab clay loam

MARION COUNTY

URAL EXPERIMENT STATION

FIG. 1.—DRAINAGE MAP OF MARION COUNTY SHOWING STREAM COURSES

the northern border. Drainage of the western part of the county is west, then south to the Mississippi river, while that of the eastern part is south to the Ohio river. Surface drainage is in the early maturity stage.

Even tho drainage channels are fairly well established thruout the county, underdrainage remains a difficult problem. The tight clay subsoil has proved to be an obstacle which yet remains economically impossible to overcome. Tiling is not successful and open surface ditching is the only practical means of removing the excess water from the land.

SOIL GROUPS

The soils of Marion county are classified under the following groups:

(a) *Upland Prairie Soils,* including the upland soils that have not been covered with heavy forests.

(b) *Upland Timber Soils,* including nearly all the upland areas which are now, or were formerly, covered with forests.

(c) *Ridge Soils,* including those formed on preglacial ridges under good drainage and well-aerated conditions. (They are designated on the map as of the 200 group, morainal soils.)

(d) *Residual Soils,* including the rock outcrops from which the loess and till have been removed by erosion.

SOILS

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Small areas rock outcrop

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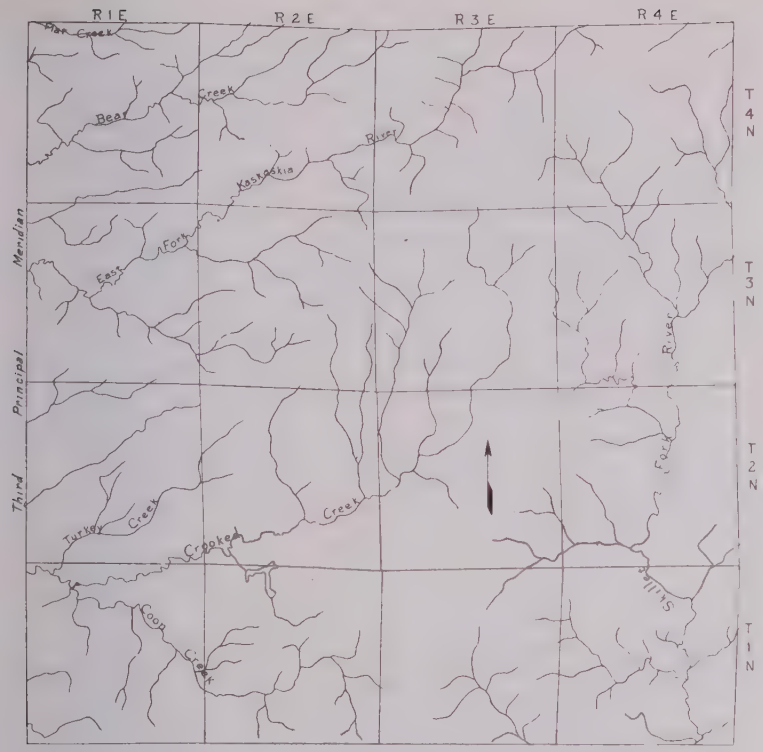
MARION COUNTY

URAL EXPERIMENT STATION



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(e) *Bottom-Land Soils,* including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

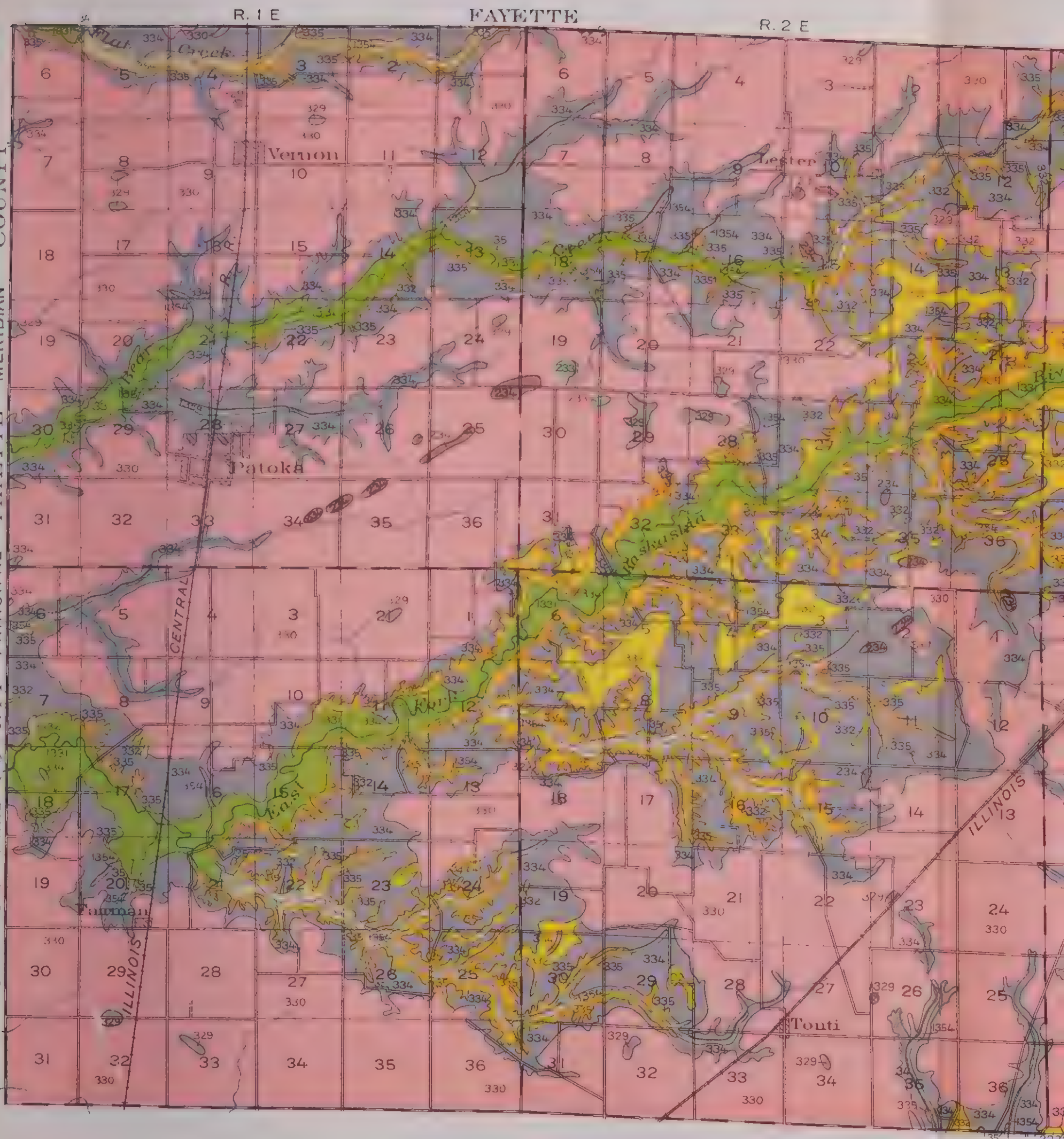
Table 1 gives the area of each type of soil in Marion county and its percentage of the total area. It will be observed that about 90 percent of the county consists of upland prairie and upland timber soils in about equal proportions. The accompanying map, appearing in two sections, shows the location and boundary lines of the various types.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix.

TABLE 1.—SOIL TYPES OF MARION COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (300)			
330	Gray Silt Loam On Tight Clay[1]	251.87	161 197	44.55
328	Brown-Gray Silt Loam On Tight Clay	.60	384	.11
329	Drab Silt Loam	2.82	1 805	.50
		255.29	163 386	45.16
	(b) Upland Timber Soils (300)			
334	Yellow-Gray Silt Loam[1]	199.73	127 827	35.32
335	Yellow Silt Loam	41.32	26 445	7.30
332	Light Gray Silt Loam On Tight Clay	15.67	10 029	2.77
		256.72	164 301	45.39
	(c) Ridge Soils (200)			
233	Gray-Red Silt Loam On Tight Clay[1]	1.57	1 005	.28
234	Yellow-Gray Silt Loam[1]	2.62	1 677	.46
		4.19	2 682	.74
	(d) Residual Soils (000)			
099	Rock Outcrop	.01	6	.001
	(e) Old Swamp and Bottom-Land Soils (1300)			
1331	Deep Gray Silt Loam	24.85	15 904	4.40
1354	Mixed Loam	23.86	15 270	4.22
1321	Drab Clay Loam	.08	51	.01
		48.79	31 225	8.63
	Water	.46	294	.08
	Total	565.46	361 894	100.00

[1]This is the name under which the type was originally mapped. Later investigation has shown the desirability of making certain differentiations within the type; these are described in the text.



LEG

000 Residual

200 Ridge Soils

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Scale

0 ¼ ½ 1 2 Miles

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(c)

233

234

SOIL SURVEY MAP

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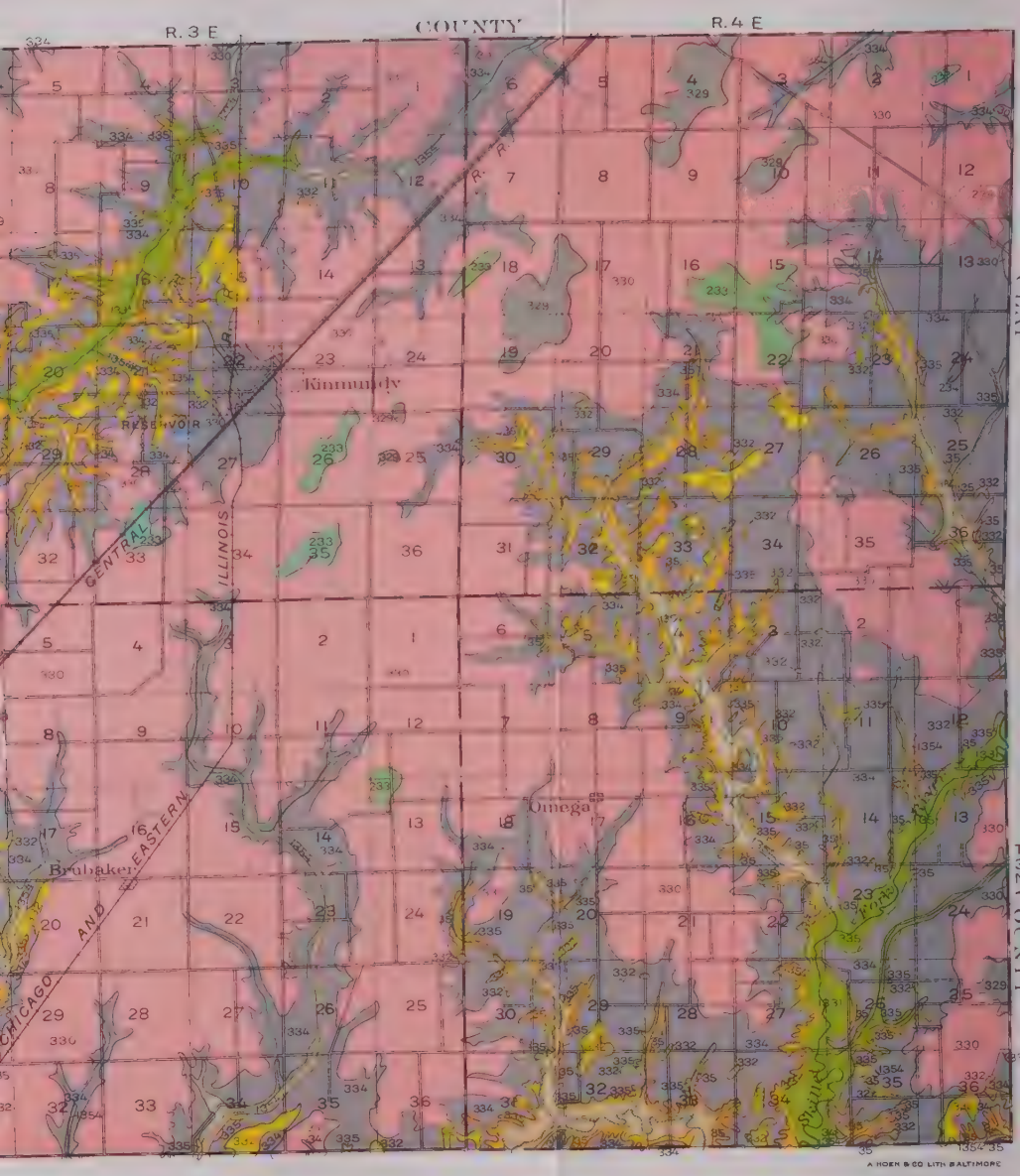

SOILS

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(d) RESIDUAL SOILS

099 Rock outcrop (sandstone)

Small areas rock outcrop

(e) 1300 OLD SWAMP AND BOTTOM-LAND SOILS

1331 Deep gray silt loam

Mixed loam

1321 Drab clay loam

MARION COUNTY

URAL EXPERIMENT STATION

INVOICE OF THE ELEMENTS OF PLANT FOOD IN MARION COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches).

These sampling strata correspond approximately in the common kinds of soil to 2 million pounds per acre of dry soil in the upper stratum, and to two times and three times this quantity in the middle and lower strata respectively. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil; but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to in describing the soil types as "horizons" A, B, and C. By this system of sampling we have represented separately three zones for plant feeding. The upper, or surface layer, includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, and other fertilizing materials are incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed. It should be understood, however, that the rate of liberation from their insoluble forms, a matter of at least equal importance, is governed by many factors, and therefore is not necessarily proportional to the total amounts present.

For convenience in making application of the chemical analyses, the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In this the assumption is made that for ordinary types a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2 million pounds. It is understood, of course, that this value is only an approximation, but it is believed that with this understanding, it will suffice for the purpose intended. It is a simple matter to convert these figures back to the percentage basis in case one desires to consider the information in that form.

With respect to the presence of limestone and acidity in different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages in the respective types, because of the extreme variations frequently found within a given soil type. In examining each soil type in the field, however, numerous qualitative tests are made which furnish general information regarding the soil reaction, and in the discussion of the individual soil types which follows, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping and soil treatment. It is often desirable, therefore, to determine the lime requirement for a

given field, and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (page 31).

THE UPPER SAMPLING STRATUM

In Table 2 are reported the total quantities of organic carbon, nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil of each type in Marion county.

In connection with this table attention is called to the variation among the soil types with respect to their content of the different plant-food elements. It will be seen from the analyses that the variation in the organic-carbon content of the different soils is accompanied by a similar variation in the nitrogen content. The organic-carbon content, which serves as a measure of the total organic matter present, is usually from 10 to 12 times that of the total nitrogen. This close relationship is explained by the well-established facts that all soil organic matter contains nitrogen, and that most of the soil nitrogen (usually 98 percent or more) is present in a state of organic combination. This close relationship is also maintained in the middle and lower sampling strata, altho it is generally a more narrow ratio at the deeper levels, owing to the more rapid dissipation of soil carbon as compared with nitrogen.

The organic matter, with the accompanying nitrogen, shows some variation among the different soil types but is comparatively low thruout the county. Of the ten soil types for which analyses are reported in this county, only two types contain more than 30,000 pounds of organic carbon in the surface stratum of an acre. These are Drab Clay Loam, Bottom, and Yellow-Gray Silt Loam, Ridge, each containing approximately 43,000 pounds an acre. The remainder of the soils in the county range in organic-carbon content from a minimum of 12,860 pounds an acre in Yellow Silt Loam, up to 29,590 pounds in Deep Gray Silt Loam, Bottom. The total nitrogen figures are correspondingly low, being in the latter two types 990 and 2,900 pounds respectively. Because of the small amounts of both nitrogen and organic matter in these soils, it is particularly important to grow legume crops frequently as green manures and plow them down, in addition to conserving and using all the animal manure which can be produced.

Other elements are not so closely associated with each other as are organic matter and nitrogen. However, there is some degree of correlation between sulfur, another element used by growing plants, and organic carbon. This is because a considerable, tho varying, proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of the organic matter. The sulfur content of Marion county soils is on the whole rather low. It ranges, in the surface soil, from 310 pounds to 1,100 pounds an acre. However, only two types, Yellow-Gray Silt Loam and Drab Clay Loam, contain more than 520 pounds.

The sulfur available to crops is affected not only by the amount and solubility of that contained in the soil, but also by the amount which is brought down from the atmosphere in the rainfall. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal, and possibly to some extent from the decay of vegetable and animal residues. The gaseous sulfur dioxid is soluble in water and consequently it is dissolved out of

the air by rain and brought to the earth. In regions of heavy coal consumption the amount of sulfur thus added to the soil is large. At Urbana, during the eight-year period from 1917 to 1924 there was added to the soil by the rainfall 3.5 pounds of sulfur per acre per month, as an average. Similar observations have been made in localities in southern Illinois for shorter periods. At Sparta, in Randolph county, in 1921, there was added in the rainfall 3.51 pounds of sulfur an acre in May, 7.78 pounds in August, and 9.96 pounds in September. At Ewing, in Franklin county, during the entire season of 1921 the average monthly precipitation contained 2.27 pounds of sulfur an acre. These figures will afford some idea of the amount of sulfur added by rain and also of the wide variation in these amounts under different conditions. On the whole, these facts would indicate that the sulfur added from the atmosphere sufficiently supplements that contained in the soil, so that a need for sulfur fertilizers is not likely in Marion county.

The potassium content of the surface soil ranges from 24,680 pounds an acre in Light Gray Silt Loam On Tight Clay to 35,300 pounds in Drab Clay Loam. From a quantitative point of view, the least of these amounts is far above maximum crop requirements. However, the rate at which potassium is liberated in available condition from these large reserves varies widely, and the statements concerning the use of potassium fertilizers in another part of this report are an indication that crop yields may be limited on some of the soils of Marion county by a deficiency of available potassium.

The phosphorus content of the soils of the county is generally low, ranging from 490 pounds an acre in Yellow Silt Loam up to 1,040 pounds in Drab Clay Loam.

The amounts of soil calcium are uniformly low, but not lower than is to be expected in mature soils which are acid. Soil acidity and calcium deficiencies are very frequently, but not always, associated. The smallest amount of calcium in the Marion county soils analyzed, 3,650 pounds an acre, is found in Yellow-Gray Silt Loam. The largest amount found is 8,160 pounds in Drab Clay Loam. These are all non-carbonate soils. Calcium is utilized by crops in fairly large amounts, so that in acid soils low in calcium content, this element possibly may not become available rapidly enough to supply crop needs. The liming of such soils, however, will supply any calcium deficiencies in addition to the correcting of acidity.

The content of magnesium in Marion county soils averages about 25 per-cent higher than that of calcium. This preponderance of magnesium is a frequent occurrence in heavy, mature soils which have been subjected to much leaching, and, as in the case here, is most pronounced in the lower levels. The smallest amount of magnesium found is 4,230 pounds an acre. Considering the crop requirements for this element, it is doubtful whether magnesium ever becomes a limiting factor in crop production. This statement, however, does not imply the superiority of high-calcium limestone as a soil amendment. The usual commercial grades of high-calcium and magnesian limestones are approximately equal in neutralizing value, and both types of stone also contain an abundance of calcium to make good any soil deficiencies in this element.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper stratum, or with each other, it is necessary to bear in mind that the data as given for the middle and lower sampling strata are on the basis of 4 million and 6 million pounds of soil, and should therefore be divided by 2 and 3, respectively, before they are compared with each other or with the data for the upper stratum, which is on a basis of 2 million pounds.

With this in mind, it will be noted in comparing the three strata with each other, that all of the soil types diminish rather rapidly in organic matter and nitrogen with increasing depth, and that this diminution is very marked even in the middle stratum. The percentages of the other elements remain about the same, or increase slightly in the lower strata with the exception of sulfur and phosphorus, which in some cases decrease with increasing depth. Phosphorus has frequently been found to be low in the middle stratum, altho this condition is not so prevalent in Marion county as is usually the case. It may be attributed

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF MARION COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES
Average pounds per acre in 2 million pounds of dry soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300)							
330	Gray Silt Loam On Tight Clay	28 550	2 840	890	520	25 730	4 230	4 480
328	Brown-Gray Silt Loam On Tight Clay	24 520	2 520	540	360	27 060	4 680	4 420
329	Drab Silt Loam	26 820	2 840	620	440	25 810	5 450	5 490
	Upland Timber Soils (300)							
334	Yellow-Gray Silt Loam	23 010	2 140	610	430	29 410	5 540	3 650
335	Yellow Silt Loam	12 860	990	490	310	35 210	7 590	3 760
332	Light Gray Silt Loam On Tight Clay	22 930	2 050	720	400	24 680	5 530	4 010
	Ridge Soils (200)							
233	Gray-Red Silt Loam On Tight Clay	27 380	2 720	760	460	27 300	5 200	4 320
234	Yellow-Gray Silt Loam	43 180	4 000	780	1 100	28 640	7 640	5 620
	Old Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam	29 590	2 900	700	510	33 070	7 300	6 620
1354	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1321	Drab Clay Loam	43 960	4 180	1 040	1 100	35 300	10 920	8 160

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF MARION COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of dry soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300)							
330	Gray Silt Loam On Tight Clay	27 280	3 070	1 050	720	55 540	9 770	8 050
328	Brown-Gray Silt Loam On Tight Clay	44 400	3 560	1 400	840	57 640	9 760	7 280
329	Drab Silt Loam	40 620	3 270	1 200	340	42 560	9 800	10 830
	Upland Timber Soils (300)							
334	Yellow-Gray Silt Loam	15 120	1 880	1 230	500	62 220	11 260	4 670
335	Yellow Silt Loam	11 730	1 550	970	450	70 750	12 710	4 690
332	Light Gray Silt Loam On Tight Clay	15 540	1 960	1 340	580	54 140	11 360	6 680
	Ridge Soils (200)							
233	Gray-Red Silt Loam On Tight Clay	29 000	3 480	1 240	...[2]...	60 680	14 880	7 760
234	Yellow-Gray Silt Loam	54 400	5 520	1 360	...[2]...	57 200	20 520	8 160
	Old Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam	20 770	3 430	1 190	570	67 090	12 910	9 110
1354	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1321	Drab Clay Loam	38 480	3 800	1 360	...[2]...	71 320	22 440	16 040

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.
[2]No analysis available; sample exhausted.

to the removal of phosphorus from this stratum by the roots of growing plants and subsequent incorporation with the surface soil in the accumulated plant residues.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is impossible to obtain this information exactly, especially for the deeper-rooted crops, it seems probable that practically all of the feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil type the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

Considered in this manner the tables reveal a considerable variation with respect to the relative abundance of the various elements among the different soil types, as measured by crop requirements. We may compare in this way two extreme soil types in the county, namely, Drab Clay Loam, Bottom, and Yellow Silt Loam, Upland. The respective amounts of nitrogen in the two soils to a depth of 40 inches are 11,640 and 4,100 pounds an acre, which is equivalent to the nitrogen contained in the same number of bushels of corn, since a bushel of corn contains approximately a pound of nitrogen. The Drab Clay Loam thus contains nearly three times as much of this element as the Yellow Silt Loam.

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF MARION COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of dry soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300)							
330	Gray Silt Loam On Tight Clay	26 710	3 300	2 080	970	83 020	28 060	18 160
328	Brown-Gray Silt Loam On Tight Clay	26 820	3 660	2 460	660	86 520	27 060	11 520
329	Drab Silt Loam	39 620	3 920	1 500	540	76 720	20 200	16 060
	Upland Timber Soils (300)							
334	Yellow-Gray Silt Loam	18 920	2 100	2 040	500	91 770	25 220	12 110
335	Yellow Silt Loam	8 560	1 560	1 340	640	101 940	27 140	9 900
332	Light Gray Silt Loam On Tight Clay	16 290	2 070	1 800	960	85 470	28 590	17 910
	Ridge Soils (200)							
233	Gray-Red Silt Loam On Tight Clay	25 020	3 360	1 800	...[2]...	87 720	19 520	16 620
234	Yellow-Gray Silt Loam	30 420	3 780	1 440	...[2]...	98 100	35 760	20 700
	Old Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam	15 520	2 280	2 220	640	104 660	26 060	10 380
1354	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1321	Drab Clay Loam	33 600	3 660	2 040	...[2]...	107 040	35 880	25 680

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.

[2]No analysis available; sample exhausted.

Drab Clay Loam also contains considerably more phosphorus than Yellow Silt Loam. The former contains 4,440 pounds of phosphorus, which is equivalent to 25,990 bushels of corn, as compared with 2,800 pounds in the latter, equivalent to 16,510 bushels of corn.

A comparison of the total amounts of potassium in the different soil types is of little direct importance when it is considered that the soil containing the smallest total amount of this element (Drab Silt Loam, 329) has in it potassium equivalent to that contained in three-quarters of a million bushels of corn. This large total supply of potassium should not be interpreted to mean that there can be no need for additions of potassium salts in crop production, for potassium minerals in the soil become soluble very slowly, and upon the rate of liberation during the growing season rests the answer to the question whether potassium should be supplied in a form readily available to crops.

The two soil types considered above vary widely in calcium content, the amounts contained to a depth of 40 inches being 49,880 pounds in Drab Clay Loam and only 18,350 pounds in Yellow Silt Loam. The relative amount of calcium is not of so great importance directly in connection with the corn crop as it is with respect to legumes. A ton of red clover hay, for example, contains approximately 29 pounds of calcium. These two soils therefore contain as much calcium as would be removed in 1,720 and 630 tons of red clover hay respectively.

The above statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration aside from merely the amount of plant-food elements present in the soil. Much depends upon the nature of the crops to be grown, as to their ability to utilize plant-food materials, and much depends upon the condition of the plant-food substances themselves as to their availability. Finally, in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon; and in this way these chemical data contribute fundamental information for the intelligent planning, in a broad way, of systems of soil management that will conserve and improve the fertility of the land.

DESCRIPTION OF SOIL TYPES

(a) UPLAND PRAIRIE SOILS

In the following descriptions of soil types an effort is made to describe the types which occur in Marion county as they are recognized at the present time. It will be observed that several of the types as they appear on the soil map, which was completed in 1915, are now recognized to include two or more types. The topographic position and the situations in which each of these new types occur is stated so that, in most cases, they can easily be recognized in the field.

The upland prairie soils of Marion county occupy 255.29 square miles, nearly one-half of the total area of the county. They range in color of surface soil from gray to grayish brown, owing to the variation in the amount and condition of the organic matter. The surface color of the prairie soils is darker than that of the timbered soils, owing to their higher content of organic matter, derived very largely from the roots of prairie grasses. If the present climatic conditions have prevailed ever since the Glacial period, it is unlikely that the soil ever contained any more organic matter or was any darker than at present. It is probable, however, that more favorable climatic conditions prevailed at some time after the retreat of the glacier, and that the soils were richer and darker, containing more organic matter which has since been reduced by the present rather high amount of rainfall, relatively open winters, and hot, dry summers. Because of their great age and loss of mineral plant food, the common prairie soils of southern Illinois have become incapable of supporting a luxuriant plant growth.

The reason for the existence of so large an extent of prairie soil in the state remains debatable. Normally forests invade and spread over the land, particularly in a country where the climate and rainfall are so nearly optimum for the development of forest vegetation as here. This prairie condition may be due to unnatural or accidental causes, such as forest fires continually nipping the new growth; but it more likely is due to the drainage conditions in the soil. Most of the prairie land is relatively flat, and prior to artificial drainage was probably

saturated with water or even covered with shallow lakes or ponds during a portion of each year. These shallow lakes or ponds were probably dry only in late summer and fall, at least not more than a few months each year. Forest vegetation would have difficulty in making a start in a soil which remained water-logged most of the year, while the prairie vegetation which matures in a relatively short time could make some growth during each dry season.

Gray Silt Loam On Tight Clay (330)

Gray Silt Loam On Tight Clay, as it was mapped in Marion county, covers an area of 251.87 square miles, or nearly 45 percent of the total area of the county. This type as originally mapped is now recognized to include several types, each with a distinct profile, and each of which is associated with a characteristic topographic expression. The original name, Gray Silt Loam On Tight Clay, has been retained for the designation of one of these types and new names applied to the others. The new names adopted are as follows: *Deep Gray Silt Loam On Tight Clay, Gray Silt Loan On Orange-Mottled Tight Clay, Yellowish Gray Silt Loam On Orange-Mottled Tight Clay, and Gray Silt Loam On Reddish Brown Clay.* The description of each of these types follows, together with a statement as to its occurrence and suggestions for its management.

Deep Gray Silt Loam On Tight Clay occurs in depressions at the heads of small streams or drainage channels, at the base of long slopes, and in level basins. The areas usually are not large, but the type is rather extensive thruout the county. This type has received, and in many places is still receiving, a silty wash, brought down in the run-off as sheet erosion during hard rains, from adjoining higher land. These low-lying, level areas originally were poorly drained and marshy, but now surface drainage is fairly well established. Inasmuch as the impervious layer lies moderately deep, underdrainage can be successfully provided in many places.

The A_1 horizon, 0 to 10 inches, is a silt loam, brownish gray in color, mealy, laminated, and friable in structure. In certain areas black iron concretions are found in this horizon. The A_2 horizon, 10 to 24 inches, is a light brownish gray to gray silt loam, mealy, friable, and iron-stained. A thin, ashy-gray layer occasionally occurs below 20 inches. The B horizon, 24 to 35 inches, is a mottled, pale yellow clay, plastic, compact, and somewhat impervious. Iron concretions are usually present in abundance. Occasionally this horizon has a drabbish cast, which probably is due to an excessively marshy condition. The C horizon, below 35 inches, is a mottled, pale yellow, friable, clayey silt loam.

Management.—Deep Gray Silt Loam On Tight Clay is medium to strongly acid to a depth of 35 or 40 inches. The portion of the type which occupies gentle slopes has good surface drainage and, with an accessible outlet, tile drainage will work satisfactorily on either the gentle slopes or on the low-lying level areas because of the depth at which the impervious layer or "tight clay" lies.

This type is low in organic matter and the first step in increasing its productivity is to add sufficient limestone for the growing of clover and then to make one of the clovers, preferably sweet clover, one of the regular crops in the

rotation. After the organic matter and nitrogen deficiency has thus been taken care of, trial should be made of one or more of the commonly used phosphates. This type, properly managed, is one of the best upland soils in the county, and can be better utilized for the production of grain crops than any other upland soil.

Gray Silt Loam On Tight Clay is found on the flat and gently undulating plains. This type includes possibly one-third of the area of the entire type as it is shown on the soil map of the county. The surface material is loess-like, but sandy, pebbly, glacial till is encountered at depths varying from 10 to 50 inches. This type presents the normal soil profile developed under conditions of exceedingly poor drainage. Its topography is flat to gently undulating, and both the surface and underdrainage are very poor.

Numerous small areas known as "slick spots" or "scalds" occur, which are easily recognized by their light gray or greenish gray color in the lower horizons when exposed in road cuts and along drainage channels. Their formation is probably associated with the movement of seepage water which has resulted in the accumulation of mineral salts and changes in the soil profile. Iron and lime are always present to some degree, and often in concretionary form. The concentration of salts in these areas inhibits plant development and often is so strong that plant growth is prevented entirely.

The A_1 horizon, 0 to 8 inches, is a brownish gray, mealy, laminated, friable silt loam. The A_2 horizon, 8 to 17 inches, is an ashy, light gray, friable silt loam. The B horizon, 17 to 28 inches, is a mottled, yellow, plastic, impervious tight clay, often containing some sand and small pebbles mixed with black iron concretions. In the "slick spots" the B, or tight clay, horizon usually occurs immediately under the A_1, or surface, and presents a very pale, greenish yellow appearance, with numerous small pebbles present. The C_1 horizon, below 28 inches, is a mottled, yellow, friable, silty clay loam containing many iron concretions, and having a distinct columnar structure for the first 8 or 10 inches.

Management.—Gray Silt Loam On Tight Clay is low in nitrogen and organic matter and is strongly acid. It has the same management requirements as Deep Gray Silt Loam On Tight Clay, described above, but will respond less favorably to good farming, because drainage is very poor, owing to the nearness of the plastic subsoil to the surface and the presence of numerous scald spots. Tile cannot be used to improve drainage on this type. If this land is to be farmed efficiently, it is necessary to use limestone and grow sweet clover. Any additional treatment should be on a trial basis. There are indications that potash salts may be used at a profit for corn and trial applications of rock or acid phosphate should be made for wheat.

This type produces good timothy hay following the application of limestone and growth of sweet clover. Redtop is a common crop on this soil, both hay and seed being produced. In growing the above crops, some sort of rotation, including a legume, should be used so that the yields may be maintained. The yield of hay or seed usually shows a marked decrease after four or five years of continuous cropping. This soil is also adapted to growing apples. It is not a good soil for

corn, but will produce satisfactory yields in seasons which are climatically favorable, if sweet clover has been grown and turned under. Wheat also may be grown, but a relatively large proportion of poor yields may be expected.

Gray Silt Loam On Orange-Mottled Tight Clay occurs on undulating to gently rolling areas. It is equally as extensive thruout the county as Gray Silt Loam On Tight Clay. The loess-like surface covering is about 30 inches deep where the sandy pebbly drift is encountered. This type was formed under poor to fair surface drainage, as is indicated by the undulating to gently rolling topography and by the character of its profile. Slick spots occur on this type but are not numerous.

The A_1 horizon, 0 to 7 inches, is a brownish gray, mealy, friable silt loam with a distinctly laminated structure. The A_2 horizon, 7 to 17 inches, is an ashy-gray, friable silt loam. The A_3 horizon, 17 to 21 inches, is an orange-mottled, ashy-gray, slightly compacted silt loam. The B_1 horizon, 21 to 26 inches, is an orange-mottled, gray, plastic, impervious tight clay. The B_2 horizon, 26 to 31 inches, is a pale yellow mottled, very compact, plastic clay with numerous iron concretions. The C horizon, below 31 inches, is a pale yellow or gray, mottled, silty clay loam with iron concretions, and a columnar structure for the first 8 or 10 inches. This horizon is more friable than either the B_1 or B_2 horizon but is not so friable as the C horizon of the two types previously described.

Management.—This type requires the same management as Gray Silt Loam On Tight Clay. It has good surface drainage and is a somewhat better soil than Gray Silt Loam On Tight Clay.

Yellowish Gray Silt Loam On Orange-Mottled Tight Clay occurs on the rolling land. The areas of this type are rather small but are scattered thruout the county. The loess-like surface covering is shallow, seldom more than 18 inches deep, the material below this being rather sandy. On account of the rolling topography, a profile was developed under fair to good surface drainage conditions. This rolling topography is due to the presence of preglacial knolls which were not smoothed off by the glacier, and to an uneven deposit of glacial drift. Most of these areas have had a light forest growth on them at some time.

The A_1 horizon, 0 to 6 inches, is a brownish yellow to brownish gray, friable silt loam with laminated structure. The A_2 horizon, 6 to 12 inches, is a yellowish gray, mealy, friable silt loam. The A_3 horizon, 12 to 16 inches, is an orange-mottled, yellowish gray, slightly compacted, silty clay loam. The B_1 horizon, 16 to 22 inches, is an orange-mottled, yellowish gray, plastic, impervious tight clay. The B_2 horizon, 22 to 27 inches, is a yellow, mottled, plastic, very compact clay with iron concretions, and often is sandy and pebbly. The C horizon, below 27 inches, is a yellow, mottled, medium-friable, silty clay loam, containing heavy iron concretions, sand, and small pebbles.

Management.—This type is medium to strongly acid in the surface soil and strongly acid in the subsoil. It is good orchard land and is also well adapted for small fruit and vegetable growing. Sufficient limestone should be applied to grow sweet clover if orchard is to be set; and if vegetables are to be grown, the same procedure should be followed unless liberal applications of manure can be made, tho an excess of limestone should be avoided.

This soil may be used for the general farm crops, and if so used, should be given the same management as recommended for Deep Gray Silt Loam On Tight Clay, page 14.

Gray Silt Loam On Reddish Brown Clay occurs on low knolls and slopes where drainage has been very good. This type is not extensive. The sandy, pebbly till is rather close to the surface; in fact, the loess-like covering is seldom more than 10 inches thick. Sheet erosion probably has removed some of the surface material from these areas.

The A_1 horizon, 0 to 9 inches, is a brownish gray, friable silt loam. The B_1 horizon, 9 to 17 inches, is a reddish brown, very compact, somewhat impervious, plastic clay. The C horizon, below 17 inches, is a brown or drabbish yellow, mottled, sandy or silty clay loam, containing iron concretions and small pebbles.

Management.—The very limited extent of this type makes its management of concern only to a few individuals. Anyone who recognizes the type as occurring on his farm is asked to write to the Experiment Station for information regarding it.

Brown-Gray Silt Loam On Tight Clay (328)

The total area of Brown-Gray Silt Loam On Tight Clay as mapped in this county is less than one square mile. It is all confined to the south-central part of the county. The topography of this type is undulating, and the drainage is poor. It differs from Deep Gray Silt Loam On Tight Clay, described above, only in that it has a slightly deeper and darker colored A horizon. The description and management of Deep Gray Silt Loam On Tight Clay (page 14) apply also to this type.

Drab Silt Loam (329)

Drab Silt Loam is not extensive, and is confined principally to three areas in the northeastern part of the county. This type occurs in low flat places which originally were very poorly drained and swampy. The areas have received a deposit of silt, varying in thickness from several inches to more than a foot, which was brought down by sheet erosion from the surrounding slopes. The drainage of this type can be improved by artificial methods, such as deep surface ditching and tiling. This type closely resembles Deep Gray Silt Loam On Tight Clay described above.

The A_1 horizon, 0 to 11 inches, is a dark gray, laminated, friable silt loam. The A_2 horizon, 11 to 26 inches, is a drabbish gray, friable silt loam, containing yellow iron concretions. The B horizon, which is variable and often deeper than 26 to 38 inches, is a yellow, mottled, drabbish gray, compact, medium-plastic clay, containing numerous iron concretions. The C horizon, below 38 inches, is a pale yellow, mottled, more friable silty clay loam, containing iron concretions.

Management.—The reader is referred to the discussion of the management of Deep Gray Silt Loam On Tight Clay, page 14, for suggestions regarding the management of Drab Silt Loam.

(b) UPLAND TIMBER SOILS

The upland timber soils of Marion county occupy 256.72 square miles, about the same area as that of the upland prairie soils. Timber appears first near the stream channels where the soil is well drained, and gradually spreads out over the prairies as the drainage lines are extended. The soil map of this county shows clearly how the timber has spread from the main drainage outlets. It also shows that in the well-drained rolling land, the timber has spread farther away from the main drainage channels, than in the flat, poorly drained areas. Much of the original timber of this county has been cut off, and the areas cultivated, but the soil still retains the effects left by the long-continued forest growth.

Timber soils are characterized by a yellowish or yellowish gray color, which is due in part to the low organic-matter content. In forests the vegetable material from trees accumulates upon the surface, and is either burned or suffers almost complete decay by being exposed to the air. Grasses, with their abundant amounts of humus-forming roots, grow but sparsely because of the shade. Moreover, the organic matter that had accumulated before the timber began growing is dissipated thru various decomposition processes, with the result that the nitrogen and organic-matter contents of the soil are low.

Japanese clover, or lespedeza, a legume which will grow in a strongly acid soil, has spread over the timber soil of this region. It affords some pasture but is particularly beneficial in retarding erosion on cleared areas by checking run-off.

Yellow-Gray Silt Loam (334)

Yellow-Gray Silt Loam occurs principally in the outer timber belts along streams and is by far the most extensive timbered soil type in the county. It covers an area of 199.73 square miles, more than one-third of the entire area of the county. The same situation exists with reference to this type, as it is shown on the soil map, as was described above in the case of Gray Silt Loam On Tight Clay. Yellow-Gray Silt Loam, as it was mapped in Marion county, is now recognized as including two types as follows: *Yellow-Gray Silt Loam On Tight Clay,* which occurs on flat, poorly drained areas, and *Yellow-Gray Silt Loam On Compact Medium-Plastic Clay,* which occurs on areas having fairly good surface drainage. This distinction is not shown on the soil map, but the types will be described separately, since they differ materially in character and in agricultural value.

Yellow-Gray Silt Loam On Tight Clay occurs thruout the county and includes more than half of the timbered soil. The surface material is loess-like. Sandy, pebbly, glacial drift is encountered at depths varying from 15 to 60 inches. This type was developed under poor drainage, and on flat to undulating topography, corresponding to the conditions under which the prairie type, Gray Silt Loam On Tight Clay, was developed. Both the surface drainage and underdrainage of this type are poor. Slick spots, as described in the above-mentioned corresponding prairie type, are found also in this type, but probably are not so numerous.

Cultivation of the virgin timber soil has produced several changes in the soil profile. Plowing, by turning up and mixing in some of the very light-colored A_2 horizon, has tended to increase the depth of the surface or A_1 horizon, as well as to lighten its color. Indications are that the depth and plasticity of the upper subsoil or B horizon are increased by continued cultivation. This would be expected, as frequent stirring of the soil should accentuate the physical movement of smaller particles downward with the drainage water.

The A_1 horizon, 0 to 5 inches, is a yellowish gray, laminated, friable silt loam. The A_2 horizon, 5 to 17 inches, is a very light yellowish gray, friable, ashy silt loam, with occasionally some black iron concretions. This horizon has a laminated structure in its upper 3 or 4 inches. The B horizon, 17 to 32 inches, is a pale yellow, mottled, plastic tight clay with iron concretions. The C_1 horizon 32 to 40 inches, is a pale yellow, mottled, compact silt loam, with distinct columnar structure. The C_2 horizon is a friable silt loam containing iron concretions.

Management.—Yellow-Gray Silt Loam On Tight Clay is acid and very low in nitrogen and organic matter. The yellowish color indicates somewhat better drainage than occurs on Gray Silt Loam On Tight Clay. Underdrainage is not successful, however, because of the impervious nature of the subsoil. The reader is referred to the discussion of Gray Silt Loam On Tight Clay, page 15, for suggestions regarding the management of this type.

Yellow-Gray Silt Loam On Compact Medium-Plastic Clay is of limited occurrence in Marion county because of the flat topography which prevails. It is found, however, in narrow belts just back of the steep, eroded land along the banks of stream channels, and following out small drainage lines. It is also found on some of the timbered glacial and preglacial knolls and ridges. The surface material is all loess-like; but sandy, pebbly, glacial drift lies from 15 to 60 inches below the surface. This type was developed under fairly good drainage conditions, on undulating to gently rolling topography.

The A_1 horizon, 0 to 7 inches, is a brownish or yellowish gray, friable, silt loam, with laminated structure. The A_2 horizon, 7 to 17 inches, is a yellowish gray, friable silt loam. The B horizon, 17 to 31 inches, is a slightly reddish or brownish yellow, mottled, compact, medium-plastic clay containing some iron concretions. The C horizon, below 31 inches, is a yellow, mottled, slightly compacted, clayey silt loam, with columnar structure for the first few inches. This horizon is friable below about 36 inches. Iron concretions, some sand, and few pebbles are found.

Management.—Yellow-Gray Silt Loam On Compact Medium-Plastic Clay is the best timber soil in Marion county. It has good surface drainage, and underdrainage probably can be successfully used. The soil is acid and in need of nitrogen and organic matter; however, it responds well to good farming; and following the use of limestone and sweet clover, good crops can be produced except in years which are climatically very unfavorable. The same suggestions regarding fertilizer treatment which were made for Gray Silt Loam On Tight Clay, page 15, apply to this type.

Yellow Silt Loam (335)

Yellow Silt Loam forms the inner timber belt along streams. It comprizes the hilly land, most of which is badly washed and all of which is subject to erosion. Fortunately the extent of this type in the county is not large. It is confined principally to Skillet Fork creek and its tributaries. Very little, if any, of this type should be cultivated. Its chief use should be for permanent pasture. Orcharding might be practiced on the more gentle slopes. A large part of the area could be profitably utilized for the regrowth of forests; in fact, all of the timber never should have been cut off. Small outcroppings of shale and sandstone rock occur on some of the steeper slopes.

Glacial till, a sandy, pebbly clay mass, is the chief material forming this type. It seldom shows any profile development because of the rapid removal of soil material by erosion. The slopes are steep, the topography is rough, and both the surface and underdrainage are good.

Management.—A very small percentage of this type is at present used for cultivated crops. It affords a little pasture, but, in the main, yields small returns. It is badly gullied and, in view of the fact that there is a large acreage of better land in the county which is not fully utilized, present conditions do not appear to warrant the expenditure of much money in its development. Some of the better areas are well adapted to orcharding but most of the type should be returned to forest.

Light Gray Silt Loam On Tight Clay (332)

Light Gray Silt Loam On Tight Clay occupies the very flat, exceptionally poorly drained areas. It is associated with Yellow-Gray Silt Loam On Tight Clay. It covers a total area of 15.67 square miles, and occurs in small areas scattered thruout the county. Its topography is very flat, and both the surface and underdrainage are very poor. During wet weather the surface soil is soft, while in dry weather it bakes and becomes very hard. These areas are spoken of as "post oak flats" or "hickory flats," because of the kind of timber which grows on them. Black iron pellets, known as "buckshot," are found on the surface.

The A_1 horizon, 0 to 4 inches, is a light yellowish gray, friable silt loam, laminated in structure and containing black iron concretions. The A_2 horizon, 4 to 16 inches, is a light gray to white, ashy silt loam. It is laminated in the upper 6 or 8 inches, and contains iron concretions. The B horizon, 16 to 35 inches, is a pale yellow, mottled, very plastic, impervious tight clay containing iron concretions. The C horizon, below 35 inches, is a pale yellow, mottled, compact silty clay loam. It contains yellow iron concretions, and has a distinct columnar structure in the upper 8 or 10 inches. Below about 35 inches, it becomes a yellow, mottled, friable silt loam. Some sand and small pebbles occur in the B and C horizons, and occasionally the compact gravelly drift is found at 36 inches. Slick spots, as described under the type Gray Silt Loam On Tight Clay, occur in this type. Cultivation of this type has produced changes in the profile such as those described under the type Yellow-Gray Silt Loam On Tight Clay.

Management.—This soil is strongly acid, very low in organic matter, and will not produce the grain crops except in the most favorable seasons. The flat topography of the type makes surface drainage difficult, and underdrainage cannot be used because of the impervious character of the subsoil. Apples do well on this soil.

(c) RIDGE SOILS

The remnants of preglacial topography, left in the form of knolls and ridges, and the accumulations of drift left by the glacier at times when its recession was interrupted, have been mapped as Ridge Soils. These higher areas vary in extent from ten to several hundred acres, and in height from 10 to 80 feet. They vary in topography from gently rolling to fairly steep, and in drainage from fair to exceptionally good. Compact pebbly drift is usually found within 40 inches of the surface, and on the preglacial knolls the depth to bed rock is seldom over 6 feet.

Gray-Red Silt Loam On Tight Clay (233)

Gray-Red Silt Loam On Tight Clay is now recognized as including two types, the characters of which have been developed under different conditions of topography and drainage. The undulating to gently rolling, fairly well-drained areas are now called *Gray Silt Loam On Orange-Mottled Tight Clay.* The rolling, well-drained areas are termed *Yellowish Gray Silt Loam On Orange-Mottled Tight Clay.* Both of these types have been described above, and the reader is referred to the descriptions and management suggestions on page 16.

Yellow-Gray Silt Loam (234)

Yellow-Gray Silt Loam, Ridge, comprizes the timbered knolls and ridges which rise from 30 to 80 feet above the surrounding country. This type is now recognized as including three types as follows: *Yellow-Gray Silt Loam On Compact Medium-Plastic Clay, Reddish Yellow-Gray Silt Loam,* and *Reddish Yellow Silt Loam.*

Yellow-Gray Silt Loam On Compact Medium-Plastic Clay occupies the undulating to gently rolling, fairly well-drained areas. This type includes most of the Yellow-Gray Silt Loam (234) as mapped. The reader is referred to the description of the upland timber type, Yellow-Gray Silt Loam On Medium-Plastic Clay, and the discussion of its management on page 19.

Reddish Yellow-Gray Silt Loam occurs only on the higher ridges in the southern part of the county and is limited in extent. It occupies steep and exceptionally well-drained areas. The surface covering is loess-like, containing more fine sand than is usual for a silt loam, and the pebbly drift is found at about 24 inches in depth. The topography is rolling and the drainage is very good.

The A_1 horizon, 0 to 8 inches, is a brownish or reddish yellow, friable silt loam with laminated structure. The A_2 horizon, 8 to 15 inches, is a grayish yellow, friable silt loam. The B horizon, 15 to 23 inches, is a reddish yellow, slightly

mottled compact silty clay loam. The C horizon, below 23 inches, is a yellow, mottled, friable, sandy and gravelly silt loam.

Management.—Reddish Yellow-Gray Silt Loam is medium acid, and is low in organic matter. It is an excellent peach soil and will produce good general farm crops after the acidity has been corrected with limestone, and the nitrogen and organic-matter deficiencies have been taken care of, preferably by the growth of sweet clover.

Reddish Yellow Silt Loam occurs only on two or three of the highest ridges in the southern part of the county. The surface covering is probably all decomposed drift, but the sandy, pebbly drift lies from 10 to 15 inches below the surface. The topography of this type is steep, and the drainage exceptionally good. Much of the surface soil is lost by gullying and sheet washing when this type of soil is cultivated.

The A_1 horizon, 0 to 10 inches, is a distinctly reddish yellow, friable silt loam. The B horizon, 10 to 21 inches, is a reddish yellow, very slightly mottled, slightly compacted silt loam, containing some sand and pebbles. The C horizon, below 21 inches, is a fairly friable, yellow, mottled, sandy, pebbly silt loam.

Management.—Reddish Yellow Silt Loam, because of its steep topography, should be used for orchard or pasture. It is an excellent orchard soil and when planted in trees can be handled in such a way as to prevent erosion.

(d) RESIDUAL SOILS

The areas mapped as residual soil include rock outcrops which are of little, if any, agricultural importance. They are found in gullies and in other places where erosion has removed the glacial drift. The outcroppings are chiefly sandstone and shale, but occasionally a thin ledge of limestone is exposed. These limestone ledges may be used as a local source for ground limestone by installing a portable crusher. They are too thin, however, to be of any general importance.

(e) OLD SWAMP AND BOTTOM-LAND SOILS

This group of soils includes the bottom lands along streams, the swamps, and the poorly drained lowlands. The soil is of alluvial formation and the land is subject to overflow. There are three types occurring in Marion county which are classed in this group.

Deep Gray Silt Loam (1331)

Deep Gray Silt Loam is the predominating bottom-land type in southern Illinois. It occupies 24.85 square miles in this county. The material forming this type is mainly a silt brought down from the surrounding hills, and deposited by slowly moving water during flood times. It has been kept under high moisture conditions thruout most of the year. The streams flowing thru these bottom lands are sluggish and meandering. The bottoms are flat and poorly drained. The soil is not of sufficient age to have any well-developed profile, as each overflow leaves some deposit on the surface.

The A_1 horizon, 7 to 10 inches, is a yellowish gray, friable silt loam with iron concretions. The A_2 horizon, below 10 inches, is a gray, slightly compacted, silt or silty clay loam, containing heavy iron concretions. In areas that are least disturbed by deposition from overflow, a compact subsoil has developed at depths varying from 18 to 22 inches. This compaction is rarely over 4 inches in thickness.

Management.—Deep Gray Silt Loam, Bottom, as it occurs in Marion county, is medium acid. About 80 percent of the type is cleared and somewhat over half of the total area is farmed. The drainage is poor, however, and this fact limits the productivity of this soil more than any other one factor. Corn is the chief crop grown. Tiling is effective on this land. On areas where the overflow and drainage can be taken care of, a very satisfactory level of productivity can easily be attained by the use of limestone and the introduction of clover as a regular crop in the rotation.

Mixed Loam (1354)

Mixed Loam is found in the small bottom lands at the heads of streams. It occupies 23.86 square miles. It overflows after each heavy rain and is continually receiving new deposits of material brought down from the adjoining upland. The soil material is mainly fine sand and silt. The areas have flat topography, and are fairly well drained. The soil shows no true profile development because of its youth. The material ranges from a yellowish gray fine sandy loam on the surface to a light yellowish gray or gray silt loam below 20 inches.

Management.—Mixed Loam, Bottom, is only slightly acid. It is subject to frequent overflow and for this reason will not become more acid with cultivation, as upland soils do. Practically the entire area of this type is farmed in corn.

Drab Clay Loam (1321)

Drab Clay Loam occupies only 51 acres, located along Crooked creek in Township 1 North, Range 1 East. Until recent years this area has been swampy. It differs from Deep Gray Silt Loam only in having more of a drabbish color and containing considerably more clay in the surface. Below 20 inches it is essentially the same as Deep Gray Silt Loam.

Management.—Drab Clay Loam, Bottom, is medium to strongly acid. It is used for corn growing and produces fairly good yields, tho not so good as those produced by Mixed Loam.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order intelligently to interpret the soil map, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items which may assist in the differentiation of types, but which are not fundamental to it, are native vegetation (whether timber or prairie), topography, and geological origin and formation.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a matured soil, three horizons designated as A, B, and C are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the A horizon.

C designates the layer lying below the B horizon and in which the material has been less affected by the weathering processes.

Frequently differences within a stratum or zone is discernible, in which case it is subdivided and described under such designations as A_1 and A_2, B_1 and B_2, etc.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized as determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers

900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *River-bottom and swamp lands,* formed by material derived from the Illinoisan or older glaciations
1400 *River-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction.

Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 7.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain.	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw..	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain...	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover...	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs....	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain...	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oats straw...	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed...	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay...	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed.	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay..	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay...	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5.
[2]Young second-year growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than

do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining

the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4, have been found satisfactory. Some commercial firms are offering other preparations which are satisfactory.

greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of mod-

erate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, acid phosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for

absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate, and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average livestock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions.

Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of finesness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This

also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the better adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to Those Occurring in Marion County)

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system. Some modifications have been introduced in recent years.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds after the first rotation, for which 4 tons was applied; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons an acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated (aP = acid phosphate, bP = bone meal, rP = rock phosphate, sP = slag phosphate)
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
Le = Legume used as green manure
Cv = Cover crop
( ) = Parentheses enclosing figures, signifying tons of hay as distinguished from bushels of seed
| = Heavy vertical rule, indicating the beginning of complete treatment
|| = Double vertical rule, indicating a radical change in the cropping system

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

THE ODIN FIELD

The Odin soil experiment field, located in Marion county about one mile southwest of Odin, is one of the oldest of the outlying University experiment fields. It was established in 1902.

The field consists of 20 acres of light-colored upland soil, mainly of the type Gray Silt Loam On Tight Clay, which is one of the prevailing prairie types of a large region in southern Illinois. A detailed examination reveals the presence of a small area in the north corner of the field of a type having a somewhat different subsoil from that of the main body of the field and designated as Gray Silt Loam On Plastic Reddish Brown Clay. There is also present near the west corner of the field a very small spot of Yellow-Gray Silt Loam, but this lies almost wholly on the border between plots, and therefore should not materially affect the experimental work. The location of these soil types, as well as the arrangement of plots, is charted on the diagram shown on the following page. The topography, or lay of the land, is indicated on this map by contour lines.

The field at present is laid out into four separate systems of plots, each system with its own plan of experimentation. An account, including complete records, of each of these plot systems follows.

Series 100, 200, 300, 400

These series are divided into two sections differing from each other with respect to underdrainage. Plots numbering from 6 to 10 inclusive are provided with a system of tile, while the corresponding plots numbering 1 to 5 inclusive are not tiled. During the period from 1907 to 1919 the northeast half of each plot was subjected to subsoil plowing in preparing the land for corn.

The rotation chiefly practiced on Series 100, 200, 300, and 400 has been corn, legumes (cowpeas or soybeans), wheat, and clover. Until 1922 the clover was alsike, soybeans being substituted if the clover failed. Since that time sweet clover has been used instead of alsike. A part of the time cowpeas were seeded in the corn, at the last cultivation.

Crop residues and cover crops have been regularly plowed down on the residue plots. The return of the wheat straw was discontinued in 1922.

In 1902 slaked lime, at the acre rate of 475 pounds, was applied to the limed plots, and in 1903 an additional 2 tons was applied to these plots. No more lime was added until 1908, after which it was applied regularly at the annual rate of 500 pounds of limestone an acre to the northwest halves and 1,000 pounds an acre to the southeast halves of these plots. In 1922 these applications were temporarily discontinued until further need for lime appears.

Phosphorus has been used in the form of steamed bone meal, which was applied at the rate of 200 pounds an acre a year until 1923, when the total amount of the bone meal was evened up on all the phosphorus plots to 4,800 pounds an acre and the application temporarily discontinued. Potassium was applied at the annual rate of 100 pounds an acre of potassium sulfate until 1923. At that time the total amount applied was evened up to 2,500 pounds and plans made to continue the application on the southwest halves of the plots at the normal rate.

Table 7 is presented as a record of the crop yields on these series since the beginning of the experiments. Table 8 summarizes the yields, by crops, for the period during which the plots have been under their full fertilizer treatment. The lower section of this table gives a more condensed summary in terms of crop

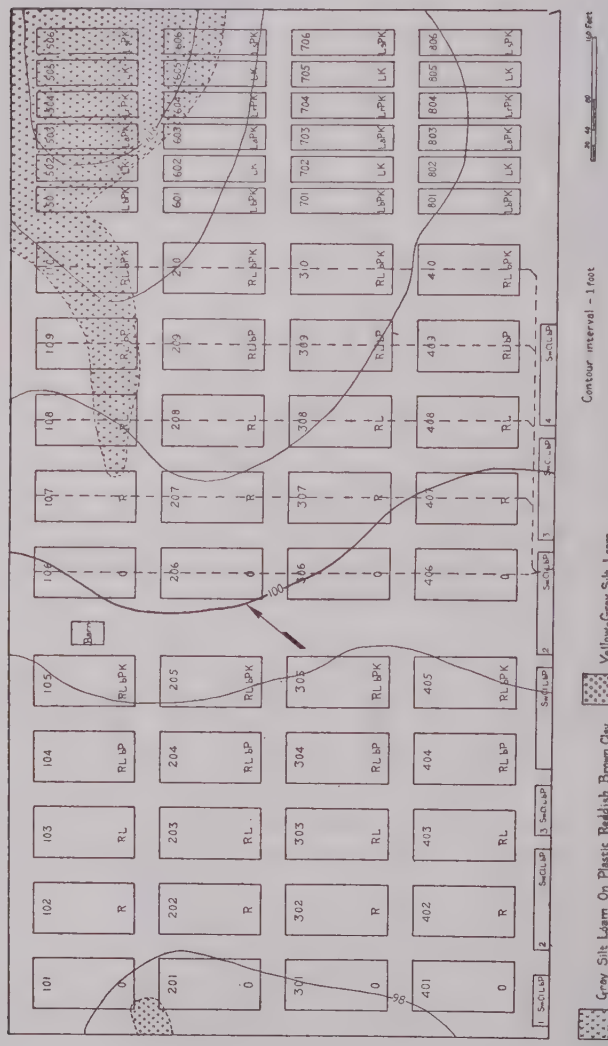
Barn
Contour interval - 1 foot
Gray Silt Loam On Plastic Reddish Brown Clay
Yellow-Gray Silt Loam
Gray Silt Loam On Tight Clay

FIG. 2.—DIAGRAM OF THE ODIN EXPERIMENT FIELD

This diagram shows the arrangement of plots, the soil treatments applied, the location of the different soil types, and by means of contour lines, the natural drainage of this field.

TABLE 7.—ODIN FIELD: SERIES 100, 200, 300, 400

Annual Crop Yields—Bushels or (tons) per acre

(1902–1914)

Plot No.	Soil treatment applied	1902 Corn[1]	1903 Oats[1]	1904 Wheat	1905 Cowpeas[2]	1906 Corn	1907 Cowpeas	1908 Wheat	1909 Cowpeas	1910 Corn	1911 Soybeans	1912 Wheat[3]	1913 Clover[2]	1914 Corn
	Land Not Tile-drained													
101	0	12.1	6.9	7.9	....	31.6	(.90)	17.3	(.65)	25.3	7.4	....	....	4.0
102	R	7.2	5.2	5.4	....	28.6	(.95)	14.4	(.67)	28.8	8.3	....	....	2.9
103	RL	8.8	6.2	10.7	....	28.5	(1.00)	18.5	(1.11)	38.0	10.1	....	....	1.8
104	RLbP	4.9	8.6	21.6	....	30.8	(1.08)	26.6	(1.30)	36.6	6.9	....	....	2.3
105	RLbPK	14.4	25.8	24.4	....	35.3	(1.80)	32.6	(1.52)	81.0	13.7	....	....	3.9
	Land Tile-drained													
106	0	11.5	8.1	6.7	....	31.7	(.76)	16.3	(.67)	26.1	8.1	....	....	4.3
107	R	13.5	8.8	8.5	....	40.1	(1.00)	21.2	(.95)	38.9	8.8	....	....	4.8
108	RL	9.7	7.2	9.6	....	34.5	(.98)	22.1	(1.02)	39.9	7.2	....	....	2.8
109	RLbP	9.5	12.3	21.5	....	33.7	(1.01)	28.9	(1.61)	42.0	7.2	....	....	2.0
110	RLbPK	20.7	28.9	25.4	....	43.9	(1.32)	34.8	(1.99)	84.5	12.6	....	....	4.1

(1915–1925)

Plot No.	Soil treatment applied	1915 Soybeans	1916 Wheat	1917 Clover[2]	1918 Corn	1919 Soybeans[4]	1920 Wheat	1920 Stubble clover	1921 Sweet clover	1922 Corn	1923 Soybeans	1924 Wheat	1925 Sweet clover	
	Land Not Tile-drained													
101	0	5.3	1.2	....	4.4	....	4.8	(0.00)	0.00	17.2	18.4	1.3	.44	....
102	R	4.7	3.7	....	6.2	....	8.8	(0.00)	.17	21.2	18.4	1.5	.24	....
103	RL	15.7	9.8	....	9.0	....	21.4	(.90)	2.00	27.5	20.7	6.8	1.44	....
104	RLbP	16.7	15.8	....	10.0	....	26.2	(.86)	1.83	27.8	18.8	12.5	.93	....
105	RLbPK	16.6	24.0	....	17.7	....	22.5	(1.79)	2.67	35.2	23.8	20.4	2.28	....
	Land Tile-drained													
106	0	10.2	.2	....	5.8	....	2.3	(0.00)	0.00	18.8	15.4	.7	0.00	....
107	R	8.2	5.4	....	7.5	....	10.4	(0.00)	.58	24.3	18.9	1.8	.44	....
108	RL	24.4	9.2	....	13.9	....	21.3	(1.19)	1.75	26.5	22.5	5.1	2.53	....
109	RLbP	15.3	17.1	....	15.6	....	26.3	(1.13)	3.33	25.5	24.3	7.5	2.24	....
110	RLbPK	10.1	21.6	....	21.8	....	22.4	(1.57)	4.25	38.4	27.0	10.7	2.38	....

[1]No residues. [2]Removed from Plots 1 and 6 and plowed under on others. [3]Crop failure. [4]Grasshoppers destroyed the crop.

TABLE 7.—ODIN FIELD, *Continued*

Bushels or (tons) per acre

(1902–1914)

Plot No.	Soil treatment applied	1902 Oats[1]	1903 Wheat	1904 Cowpeas[2]	1905 Corn	1906 Cowpeas	1907 Wheat	1908 Cowpeas	1909 Corn	1910 Soybeans	1911 Wheat	1912 Soybeans	1913 Corn	1914 Soybeans
	Land Not Tile-drained													
201	0	15.8	.4	....	36.1	(.93)	14.2	1.7	27.9	8.3	5.3	11.7	3.7	4.4
202	R	16.1	.6	....	46.7	(1.08)	15.1	2.9	31.3	9.8	5.8	17.1	5.4	4.9
203	RL	14.1	.7	....	59.9	(.93)	18.6	2.5	27.3	5.3	15.0	20.4	4.2	5.0
204	RLbP	16.7	5.8	....	57.7	(1.25)	26.8	2.3	35.2	8.8	16.6	21.5	4.3	5.2
205	RLbPK	18.8	14.0	....	79.5	(2.47)	29.8	4.6	69.1	11.7	19.2	27.9	11.7	6.7
	Land Tile-drained													
206	0	12.2	.6	....	42.6	(.83)	14.3	1.4	25.5	6.6	4.9	5.6	2.0	3.6
207	R	10.3	.6	....	37.4	(1.03)	16.9	2.3	26.3	6.8	6.7	6.1	2.1	3.8
208	RL	11.7	2.1	....	57.9	(1.30)	21.1	2.7	30.4	9.6	9.4	12.4	4.0	7.8
209	RLbP	19.2	13.4	....	65.8	(1.68)	29.5	1.8	41.3	8.7	19.5	16.7	9.7	8.7
210	RLbPK	17.7	15.2	....	71.6	(2.27)	31.8	3.9	55.3	14.3	23.2	23.1	8.6	7.6

(1915–1925)

Plot No.	Soil treatment applied	1915 Wheat	1916 Clover	1917 Corn	1918 Soybeans	1919 Wheat	1920 Clover	1921 Corn	1922 Soybeans	1923 Wheat	1924 Sweet clover	1925 Corn		
	Land Not Tile-drained													
201	0	11.9	.42	8.4	3.6	18.7	(0.00)	11.6	4.2	2.5	0.00	23.1	....	....
202	R	15.0	1.25	10.2	5.8	13.5	(0.00)	14.1	4.0	2.7	0.00	31.9	....	....
203	RL	16.0	1.67	7.5	7.4	26.7	(1.66)	10.4	6.6	6.3	1.17	26.6	....	....
204	RLbP	25.0	1.67	9.5	7.2	35.1	(1.86)	9.3	6.4	9.2	.67	24.8	....	....
205	RLbPK	29.7	1.83	33.7	5.8	37.2	(2.47)	25.0	10.3	21.4	1.42	43.7	....	....
	Land Tile-drained													
206	0	14.3	.92	10.4	5.0	14.2	(0.00)	7.3	3.8	1.3	0.00	16.2	....	....
207	R	14.3	1.50	14.1	5.4	20.1	(0.00)	6.9	4.0	1.4	.25	18.1	....	....
208	RL	25.9	3.08	15.5	7.8	33.5	(1.64)	9.7	8.3	7.8	1.92	28.2	....	....
209	RLbP	29.6	2.83	18.1	8.0	35.4	(1.61)	16.1	8.8	18.3	1.25	31.6	....	....
210	RLbPK	31.8	2.00	27.4	3.2	36.1	(1.98)	15.8	8.2	27.9	1.92	39.9	....	....

[1]No residues. [2]Removed from Plots 1 and 6 and plowed under on others.

TABLE 7.—ODIN FIELD, *Continued*

Bushels or (tons) per acre

(1902–1914)

Plot No.	Soil treatment applied	1902 Corn[1]	1903 Cowpeas[2]	1904 Corn	1905 Oats	1906 Wheat	1907 Cowpeas	1908 Corn	1909 Soybeans	1910 Wheat	1911 Soybeans	1912 Corn	1913 Soybeans	1914 Wheat
	Land Not Tile-drained													
301	0	19.5	....	53.1	23.0	12.1	(1.24)	39.3	7.4	11.7	11.3	30.3	3.0	5.0
302	R	10.7	....	48.8	19.4	13.7	(1.29)	31.4	9.2	7.8	11.7	27.8	2.9	2.7
303	RL	8.8	....	44.1	30.3	19.2	(.87)	33.0	5.0	26.3	6.9	44.2	2.4	14.9
304	RLbP	10.7	....	44.1	39.2	21.1	(.94)	43.0	5.2	32.4	9.5	46.6	3.1	15.4
305	RLbPK	14.5	....	66.6	31.9	29.2	(2.13)	66.4	2.8	34.1	14.0	63.0	3.8	17.9
	Land Tile-drained													
306	0	7.5	....	29.4	24.8	11.2	(1.24)	28.6	3.4	6.3	6.1	27.7	3.4	2.4
307	R	10.0	....	31.6	24.5	15.5	(1.34)	28.3	3.9	4.4	6.8	35.7	2.9	2.8
308	RL	10.0	....	42.8	22.0	20.7	(1.14)	37.5	3.0	19.6	5.8	51.9	5.0	19.0
309	RLbP	15.6	....	45.9	26.3	24.8	(.94)	42.6	1.4	31.3	7.0	55.9	4.6	20.0
310	RLbPK	16.3	....	64.1	31.1	31.5	(2.31)	70.0	4.5	29.2	12.7	50.9	5.7	20.8

(1915–1925)

Plot No.	Soil treatment applied	1915 Soybeans	1916 Corn	1917 Soybeans	1918 Wheat	1919 Soybeans[3]	1920 Corn	1921 Soybeans	1922 Wheat	1922 Stubble clover	1923 Sweet clover	1924 Corn	1925 Soybeans	
	Land Not Tile-drained													
301	0	3.9	15.8	3.1	5.2	....	25.1	8.3	13.1	(0.00)	0.00	6.3	(.96)	....
302	R	2.0	18.0	4.2	5.5	....	28.0	8.7	13.1	(0.00)	.17	15.3	(.98)	....
303	RL	7.6	22.8	5.7	20.8	....	32.5	11.1	25.9	(.85)	.17	48.0	(1.34)	....
304	RLbP	8.6	21.4	4.9	25.8	....	27.4	9.8	23.3	(.79)	.14	47.1	(1.19)	....
305	RLbPK	10.4	25.7	7.3	28.4	....	43.6	11.6	24.8	(.85)	.10	65.5	(1.52)	....
	Land Tile-drained													
306	0	4.3	10.0	4.4	1.0	....	18.7	7.0	5.3	(0.00)	0.00	5.5	(.74)	....
307	R	5.2	14.2	5.8	2.0	....	19.1	7.3	5.3	(0.00)	0.00	15.2	(.68)	....
308	RL	11.5	17.7	6.8	15.8	....	22.2	9.1	24.8	(.59)	.21	49.7	(1.09)	....
309	RLbP	10.3	18.0	6.9	23.1	....	20.9	9.2	25.8	(.63)	.20	46.2	(1.44)	....
310	RLbPK	10.7	33.2	8.5	29.0	....	37.7	12.3	24.5	(.80)	.14	59.4	(1.46)	....

[1]No residues. [2]Removed from Plots 1 and 6 and plowed down on others. [3]Grasshoppers destroyed crop.

TABLE 7.—ODIN FIELD, *Concluded*

Bushels or (tons) per acre

(1902–1914)

Plot No.	Soil treatment applied	1902[1] Cowpeas[2]	1903 Corn	1904 Oats	1905 Wheat	1906 Clover	1907 Corn	1908 Soybeans	1909 Wheat	1910 Cowpeas	1911 Corn	1912 Soybeans	1913 Wheat	1914 Soybeans
						Land Not Tile-drained								
401	0	(2.09)	17.9	28.6	15.2	(.22)	48.8	8.6	14.6	(.95)	21.2	13.9	18.5	7.8
402	R	....	16.6	36.7	16.6	(.28)	44.4	11.7	15.3	(.93)	23.5	17.8	16.7	8.0
403	RL	....	20.2	41.4	24.8	(.32)	45.3	14.0	20.3	(.66)	22.3	18.2	28.2	14.2
404	RLbP	....	18.3	39.8	36.5	(.34)	45.7	16.8	27.2	(.52)	21.2	13.7	35.0	12.3
405	RLbPK	....	22.3	39.7	35.8	(1.27)	67.1	19.3	31.8	(.96)	43.4	15.4	33.2	12.4
						Land Tile-drained								
406	0	(1.88)	8.7	25.1	10.8	(.37)	33.2	7.8	14.0	(.65)	8.9	8.8	16.2	5.9
407	R	....	12.8	33.4	18.7	(.36)	48.8	7.8	18.4	(.65)	15.4	11.4	24.2	9.4
408	RL	....	17.6	53.3	23.9	(.50)	49.3	11.8	19.4	(.46)	25.1	17.4	31.4	12.2
409	RLbP	....	15.9	44.8	35.3	(.63)	45.6	12.8	25.4	(.41)	21.5	18.7	36.9	9.8
410	RLbPK	....	15.0	43.1	28.4	(1.31)	62.3	13.0	27.8	(.99)	32.7	25.2	40.7	8.2

(1915–1925)

Plot No.	Soil treatment applied	1915 Corn	1916 Soybeans	1917 Wheat	1918 Clover[2]	1919 Corn	1920 Soybeans	1921 Wheat	1921 Stubble clover	1922 Sweet clover	1923 Corn	1924 Soybeans	1925 Wheat	
						Land Not Tile-drained								
401	0	43.7	6.0	20.1	....	.6	13.9	11.3	(0.00)	0.00	26.2	7.9	6.3	....
402	R	47.0	8.3	16.9	....	.9	15.1	8.3	(0.00)	0.00	19.5	9.3	10.7	....
403	RL	46.3	7.6	26.0	....	4.0	17.8	20.5	(.56)	3.79	20.3	12.1	26.1	....
404	RLbP	43.5	4.8	28.2	....	2.1	15.8	25.0	(.61)	2.50	13.6	7.7	27.1	....
405	RLbPK	58.2	5.8	27.8	....	1.9	24.4	26.9	(.94)	3.75	46.2	15.0	27.5	....
						Land Tile-drained								
406	0	23.4	5.6	11.0	....	.2	8.5	11.8	(0.00)	0.00	19.9	2.8	.8	....
407	R	36.7	7.1	21.6	....	.2	15.4	15.0	(0.00)	0.00	24.2	7.5	9.0	....
408	RL	45.3	5.8	19.7	....	1.7	14.8	22.2	(.22)	.83	9.7	10.4	21.6	....
409	RLbP	41.7	4.1	23.1	....	2.0	16.9	26.5	(.33)	.83	12.2	10.0	27.3	....
410	RLbPK	49.2	7.5	24.8	....	4.3	18.4	26.9	(.75)	2.04	40.4	17.9	23.7	....

[1]No residues. [2]Removed on Plots 1 and 6 and plowed under on others.

TABLE 8.—ODIN FIELD: SERIES 100, 200, 300, 400
Average Annual Yields 1903–1925—Bushels or (tons) per acre

Serial Plot No.	Soil treatment applied[1]	Corn	Soy-beans	Wheat	Alsike clover		Sweet clover	Stubble clover	Cowpeas	
					Hay	Seed			Hay	Seed
		22 crops	*19 crops*	*23 crops*	*2 crops*	*1 crop*	*3 crops*	*2 crops*	*8 crops*	*1 crop*
1	0	22.8	8.1	9.5	(.11)	.42	0.00	(0.00)	(.58)	1.7
2	R	23.5	9.3	9.3	(.14)	1.25	.06	(0.00)	(.62)	2.9
3	RL	27.1	10.9	17.5	(.99)	1.67	1.71	(.70)	(.57)	2.5
4	RLP	27.1	10.3	22.5	(1.10)	1.67	1.10	(.70)	(.64)	2.3
5	RLPK	43.7	13.3	25.8	(1.87)	1.83	1.76	(.90)	(1.11)	4.6
6	0	17.7	6.4	7.2	(.19)	.92	0.00	(0.00)	(.52)	1.4
7	R	22.0	7.7	10.6	(.18)	1.50	.08	(0.00)	(.62)	2.3
8	RL	27.5	10.8	17.6	(1.07)	3.08	.99	(.41)	(.61)	2.7
9	RLP	29.0	10.6	23.8	(1.12)	2.83	.76	(.48)	(.71)	1.8
10	RLPK	40.5	13.0	25.6	(1.65)	2.00	1.37	(.78)	(1.11)	3.9
	R over 0	2.5	1.3	1.6	(.01)	.71	.07	(0.00)	(.07)	.1
	RL over R	4.6	2.4	7.6	(.87)	1.00	1.28	(.56)	(−.03)	0.0
	RLP over RL	.8	−.4	5.6	(.08)	−.13	−.42	(.04)	(.09)	−.6
	RLPK over RLP	14.1	2.7	2.7	(.65)	−.34	.59	(.25)	(.44)	2.3

[1]Plots 1 to 5 not tiled; Plots 6 to 10 tiled.

increases, indicating the effects of the different fertilizing materials as they were used in these experiments. The figures given are derived from the results of the corresponding tiled and untiled plots averaged together.

Organic manure is provided in these experiments by plowing under crop residues and legume crops used as green manure. The crop yields show little effect from residues alone. Residues with limestone, however, have produced, with a single exception, notable increases in yields. It is of interest to note that the one crop which does not show a beneficial effect from limestone is cowpeas, and the cowpea is generally known as a plant tolerant to soil acidity.

Regarding the phosphorus treatment on these series it will be observed that wheat shows a marked benefit from bone meal, but the other crops have responded

FIG. 3.—WHEAT ON THE ODIN FIELD IN 1920

At the left is a check plot, receiving no soil treatment, where the average yield of wheat for 23 crops has been 8.4 bushels an acre. At the right, thru the use of limestone and crop residues, this yield was doubled. By adding bonemeal to this treatment, another increase was produced, bringing the yield up to 23.2 bushels.

FIG. 4.—CORN YIELD DOUBLED BY SOIL TREATMENT ON THE ODIN FIELD IN 1923

The pile of corn at the right was produced on a plot receiving no soil treatment. The pile at the left was produced on a plot receiving crop residues, limestone, bonemeal, and potassium sulfate.

indifferently. With a single exception, the potassium treatment has been attended by some increase in yield, and in the case of the corn this increase is very pronounced.

So far as the effect of tiling is concerned, the average results show no consistent differences of consequence between the plots of the tiled section and those of the untiled section. It is probably on account of the impervious nature of the subsoil that the presence of the tile has had little effect on the drainage.

These results on the whole point to the necessity of using limestone with organic manures in improving this soil. The organic manure has been supplied in these experiments by crop residues and legumes, but on the farm, of course, all available stable manure should be utilized.

Experiments in Subsoiling

In order to learn whether something could be done to overcome the unfavorable subsoil condition in this kind of land, by subsoil plowing, an experiment was started in 1907 and continued for thirteen years. In this experiment one-half of each plot in both tiled and untiled sections was plowed and subsoiled, with a few exceptions, in the late fall. The effect on crop yields was measured only in the corn, this crop being harvested by half plots. The yields are given in Table 9, the figures representing the averages for corresponding tiled and untiled plots.

The general averages for the entire thirteen-year period show only insignificant differences in yield between subsoiled plots and plots not subsoiled. Indeed these differences are so small that they may be regarded as being within the experimental error, and the only conclusion warranted is that the expensive practice of subsoiling has produced no significant effect upon the yield of corn in this investigation.

For a more detailed account of this experiment in subsoiling, the reader is referred to Bulletin 258 of this Station.

TABLE 9.—ODIN FIELD: EXPERIMENTS IN SUBSOILING
Yields of Corn—Bushels per acre

Soil treatment	None		R		RL		RLP		RLPK	
Tillage treatment	Not subsoiled	Subsoiled	Not subsoiled	Subsoiled	Not subsoiled	Subsoiled	Not subsoiled	Subsoiled	Not subsoiled	Subsoiled
1907[1]	44.4	37.6	50.1	43.2	47.3	47.3	47.0	44.4	70.1	59.4
1908[1]	35.5	32.5	33.2	26.4	35.5	34.9	39.9	45.9	76.1	60.3
1909	29.3	24.1	30.4	27.2	29.2	28.5	28.9	37.6	54.0	60.4
1910	28.9	22.5	32.8	35.1	40.3	37.5	38.7	39.9	79.9	85.7
1911	16.8	13.3	19.0	19.9	24.7	22.7	22.8	19.9	35.7	40.4
1912[2]	26.1	31.7	39.6	24.0	48.6	47.5	49.4	53.1	65.4	48.5
1913[1]	2.5	3.2	3.9	3.6	4.1	4.1	6.1	7.9	10.1	10.2
1914[1]	4.3	4.0	3.3	4.3	2.1	2.4	2.0	2.5	3.1	5.0
1915[1]	35.3	31.7	40.5	43.3	47.6	44.0	43.2	41.9	57.4	50.0
1916[1]	13.4	12.4	15.7	16.5	19.5	21.0	19.5	19.9	31.9	27.0
1917	9.3	9.5	14.1	10.3	11.2	11.8	13.8	13.8	30.9	30.2
1918[1]	4.2	6.0	7.4	6.3	11.5	11.3	12.8	12.7	19.8	19.7
1919	.5	.3	.7	.4	2.8	3.0	1.9	2.3	3.5	3.3
Average	19.9	17.7	22.3	20.0	24.7	24.3	25.0	26.3	41.3	38.4

[1]Replowed in spring. [2]Plowed and subsoiled in spring.

Comparative Phosphate Tests

The land included in the present Series 500, 600, 700, and 800 was originally plotted as one series of six long plots designated as Series 500 and used for the purpose of studying the relative value of various carriers of phosphorus applied in amounts equivalent to equal money values on limed and unlimed land.

A rotation of corn, oats, and three years of clover-timothy meadow was first established on this series. Cowpeas were seeded in the corn for use as residues. The phosphates were applied at the annual acre rate of 200 pounds of steamed bone meal, 333 pounds of acid phosphate, 666 pounds of rock phosphate, and 250 pounds of slag phosphate, amounts representing equivalent money value at the time these experiments were planned. The first application of lime was at the acre rate of 1½ tons to the southeast halves. Subsequent applications were at the annual acre rate of 1,000 pounds. Potassium at the annual acre rate of 100 pounds of potassium sulfate was applied to all plots. These applications were discontinued in 1913.

The annual yields from these plots are given in detail in Table 10, and the results are summarized by crops in Table 11. The lower part of Table 11 shows differences in crop yields presumed to have resulted from applying the various forms of phosphatic fertilizers for all the crops harvested from 1904 up to 1921, after which time the plot treatments were modified. Altho it is recognized that these data are too meagre for final conclusions, the following comments based upon these figures for crop increases may be made.

It appears that the various phosphorus carriers—bone meal, acid phosphate, rock phosphate, and slag phosphate—rank differently in efficiency, according to the kind of crop produced. Considering first the results without limestone, we find the following order of efficiency: for corn—bone, acid, slag, rock; for oats—acid, either bone or rock, slag; and for hay—bone, slag, either acid or rock.

TABLE 10.—ODIN FIELD: COMPARATIVE PHOSPHATE TEST

Annual Crop Yields—Bushels or (tons) per acre

(1904–1912)

Plot No.	Soil treatment applied	1904 Corn[1]	1905 Oats	1906 Timothy	1907 Timothy	1908 Timothy and clover	1909 Corn	1910 Oats	1911 Timothy	1912 Timothy
501 NW	RK, *bone* phosphate	52.5	22.6	(.82)	(1.06)	(1.09)	39.1	55.6	(.55)	(1.26)
501 SE	RKL, *bone* phosphate	53.8		(.85)	(1.64)	(1.88)	45.3	55.5	(.93)	(1.50)
502 NW	RK	41.0	24.4	(.64)	(.98)	(.72)	39.5	44.1	(.35)	(.67)
502 SE	RKL	33.8		(.96)	(1.06)	(1.46)	44.2	48.5	(.92)	(1.31)
503 NW	RK, *acid* phosphate	50.0	27.1	(.71)	(1.01)	(.70)	38.3	53.9	(.83)	(.93)
503 SE	RKL, *acid* phosphate	49.0		(1.06)	(1.19)	(1.45)	39.9	42.8	(1.05)	(1.39)
504 NW	RK, *rock* phosphate	46.8	26.4	(.64)	(.91)	(.67)	32.5	50.5	(.59)	(.95)
504 SE	RKL, *rock* phosphate	49.5		(1.08)	(1.20)	(1.63)	44.7	52.4	(1.25)	(1.52)
505 NW	RK	33.0	27.4	(.57)	(.85)	(.47)	31.1	40.1	(.24)	(1.12)
505 SE	RKL	38.5		(1.04)	(1.14)	(1.29)	41.5	50.0	(.99)	(1.52)
506 NW	RK, *slag* phosphate	46.0	25.2	(.64)	(.94)	(.74)	34.0	47.6	(.48)	(1.13)
506 SE	RKL, *slag* phosphate	51.0		(.87)	(1.48)	(1.66)	44.9	61.4	(1.17)	(1.38)

(1913–1921)

Plot No.	Soil treatment applied	1913 Timothy	1914 Corn	1915 Oats	1916 Timothy and clover	1917 Timothy	1918 Timothy	1919 Corn	1920 Oats[2]	1921 Timothy and clover
501 NW	RK, *bone* phosphate	(.84)	2.6	74.5	(1.19)	(1.61)	(2.11)	.2	.....	(0.00)
501 SE	RKL, *bone* phosphate	(1.03)	2.7	65.4	(1.10)	(1.75)	(1.63)	2.2	.....	(1.91)
502 NW	RK	(.49)	2.4	62.8	(.49)	(.75)	(1.14)	.1	.....	(0.00)
502 SE	RKL	(.73)	2.2	58.9	(.98)	(1.64)	(1.44)	4.3	.....	(2.31)
503 NW	RK, *acid* phosphate	(.47)	1.4	77.5	(.57)	(.62)	(.93)	.3	.....	(0.00)
503 SE	RKL, *acid* phosphate	(1.00)	1.8	60.6	(1.04)	(1.73)	(1.44)	4.0	.....	(1.91)
504 NW	RK, *rock* phosphate	(.55)	1.6	79.8	(.51)	(.76)	(1.18)	.1	.....	(0.00)
504 SE	RKL, *rock* phosphate	(1.02)	2.6	66.4	(1.09)	(1.67)	(1.44)	5.1	.....	(1.67)
505 NW	RK	(.41)	1.0	55.8	(.33)	(.44)	(.72)	.1	.....	(0.00)
505 SE	RKL	(.76)	1.8	66.9	(1.03)	(1.47)	(1.37)	5.4	.....	(1.75)
506 NW	RK, *slag* phosphate	(.72)	1.8	78.0	(.87)	(.83)	(1.13)	.1	.....	(.30)
506 SE	RKL, *slag* phosphate	(1.04)	2.2	80.8	(1.08)	(1.52)	(1.52)	2.6	.....	(1.64)

[1]No residues. [2]Crop failure.

TABLE 11.—ODIN FIELD: COMPARATIVE PHOSPHATE TESTS
Summary of Crop Yields 1904–1921—Bushels or (tons) per acre

Plot No.	Soil treatment applied	Corn *4 crops*	Oats *3 crops*	Hay *10 crops*
501 NW	RK, *bone* phosphate	23.6	43.4	(1.05)
501 SE	RKL, *bone* phosphate	26.0	40.3	(1.42)
502 NW	RK	20.8	35.6	(.62)
502 SE	RKL	21.1	35.8	(1.28)
503 NW	RK, *acid* phosphate	22.5	43.8	(.68)
503 SE	RKL, *acid* phosphate	23.7	34.5	(1.33)
504 NW	RK, *rock* phosphate	20.3	43.4	(.68)
504 SE	RKL, *rock* phosphate	25.5	39.6	(1.36)
505 NW	RK	16.3	32.0	(.52)
505 SE	RKL	21.8	39.0	(1.24)
506 NW	RK, *slag* phosphate	20.5	41.9	(.78)
506 SE	RKL, *slag* phosphate	25.2	47.4	(1.34)
	RKbP over RK	5.1	9.6	(.48)
	RKLbP over RKL	4.5	2.9	(.16)
	RKaP over RK	4.0	10.0	(.11)
	RKLaP over RKL	2.2	−2.9	(.07)
	RKrP over RK	1.8	9.6	(.11)
	RKLrP over RKL	4.0	2.2	(.10)
	RKsP over RK	2.0	8.1	(.21)
	RKLsP over RKL	3.7	10.0	(.08)

Used with limestone, the relative efficiencies run as follows: for corn—bone, rock, slag, acid; for oats—slag, bone, rock, acid; and for hay—bone, rock, slag, acid. In general, the differences are small and a careful analysis of the data shows that most of them are to be considered insignificant, that is to say, well within the experimental error.

These results illustrate well the difficulty of laying down definite rules for practice in applying phosphorus fertilizer. To this point in the discussion there has been taken into account only the effect on production. When the economy from a financial standpoint is considered, the matter becomes more complicated, for all depends upon relative cost of materials applied as well as upon the market value of produce sold, both of which are constantly fluctuating. However, with the data of Table 11, one may compute for himself the relative economy of producing these crop increases by applying any set of prices for crops and fertilizers which appears to be most applicable according to prevailing market conditions. In so doing, however, it should constantly be borne in mind that the order of efficiency might easily be shifted thru a relatively small change in commodity prices.

In 1922 this series was replotted into the present 500, 600, 700, and 800 series, and a different system of rotation established for further investigation of the various forms of phosphorus fertilizer. Limestone at the rate of one ton an acre was applied for the first time to the originally unlimed areas, and further

TABLE 12.—ODIN FIELD: COMPARATIVE PHOSPHATE TESTS, REVISED
Annual Crop Yields 1922–1925—Bushels per acre

Plot No.	Soil treatment applied[1]	1922 Corn[2]	1923 Wheat[2]	1924 Corn	1925 Wheat
501	LeLK, *bone* phosphate	36.6	17.5	24.0	15.2
502	LeLK	24.6	6.0	27.4	8.7
503	LeLK, *acid* phosphate	32.8	14.5	21.6	12.3
504	LeLK, *rock* phosphate	32.6	13.3	29.2	14.5
505	LeLK	21.2	6.2	23.6	7.3
506	LeLK, *slag* phosphate	30.2	16.0	42.4	14.5
		Oats[2]	Corn	Wheat	Corn
601	LeLK, *bone* phosphate	1.9	10.8	22.5	24.0
602	LeLK	1.6	7.2	1.0	25.8
603	LeLK, *acid* phosphate	1.9	9.8	18.8	30.4
604	LeLK, *rock* phosphate	1.9	8.8	10.8	18.0
605	LeLK	1.9	10.2	.7	15.6
606	LeLK, *slag* phosphate	5.0	17.2	13.5	11.6
		Corn[2]	Wheat[2]	Corn	Wheat
701	LeLK, *bone* phosphate	20.4	24.7	24.4	24.2
702	LeLK	20.0	24.2	28.0	25.5
703	LeLK, *acid* phosphate	19.8	19.8	33.8	20.8
704	LeLK, *rock* phosphate	19.6	18.0	40.8	22.0
705	LeLK	23.0	18.7	45.8	17.3
706	LeLK, *slag* phosphate	25.2	21.2	26.4	23.0
		Oats[2]	Corn	Wheat	Corn
801	LeLK, *bone* phosphate	6.6	35.6	17.2	39.8
802	LeLK	6.9	33.2	18.8	42.8
803	LeLK, *acid* phosphate	7.8	35.0	17.2	41.0
804	LeLK, *rock* phosphate	7.5	28.8	18.3	42.2
805	LeLK	10.6	29.2	15.8	44.2
806	LeLK, *slag* phosphate	7.5	29.0	21.7	44.0

[1] Series 500 and 600 have received 1 ton of limestone per acre; Series 700 and 800 have received 8 tons per acre.

[2] No legume treatment.

application is to be deferred until a need for it appears. No limestone was applied to Series 700 and 800, which had been limed originally. No phosphates have been applied since 1919 and no further applications will be made for an indefinite period. For the time being, a crop rotation of corn and wheat with sweet clover seeding will be practiced on Series 500 and 600 and repeated on Series 700 and 800. The results for the four years during which this work has been running are given as a matter of record in Table 12, but because of the small number of crops that can be included, no attempt is made at this time to summarize these results or to discuss them.

Experiments with Sweet Clover in Rotations

In addition to the above described series, seven plots on the Odin field have been devoted to two special rotations featuring sweet clover. On three plots a rotation of corn, cowpeas or soybeans, and wheat has been practiced. Sweet clover has been seeded in both the corn and the wheat and plowed down as a green manure for the succeeding crop. On the other four plots the rotation has been corn, cowpeas or soybeans, wheat, and sweet clover. In this system the sweet clover has been allowed to make its second year's growth and produce a seed

TABLE 13.—ODIN FIELD: SWEET-CLOVER ROTATIONS
Annual Crop Yields 1906-1925—Bushels or (tons) per acre

Year	Three-year rotation			Four-year rotation			
	Corn	Soy-beans	Wheat	Corn	Soy-beans	Wheat	Sweet clover
1906	38.3	(1.90)[1]	28.3	24.0	(1.60)[1]	32.7	[4]
1907	46.8	(1.27)[1]	24.0	51.5	(1.39)[1]	30.0	[4]
1908	48.0	9.6	30.7	58.3	8.8	27.7	[4]
1909	24.4	.7	23.3	39.2	1.5	25.5	[4]
1910	32.7	3.9	39.4[3]	41.3	5.0	70.3[3]	6.90
1911	25.3	8.0	12.8	59.5	7.1	17.2	3.60
1912	54.4	11.1	[2]	68.4	18.6	[2]	[4]
1913	7.3	[2]	22.7	10.3	3.9	40.8	[4]
1914	7.3	2.2	12.8	2.0	4.4	23.3	[6]
1915	42.0	1.7	27.8	59.7	1.7	24.7	.83
1916	18.4	.6	2.2	19.8	8.0	2.2	2.78
1917	14.0	5.0	10.0	19.7	11.1	39.2	1.25
1918	5.5	3.3	24.4	2.6	.8	23.0	[2]
1919	.7	[5]	32.8	7.7	[5]	26.7	[2]
1920	54.7	19.4	[2]	66.7	21.1	[2]	1.94
1921	20.7	8.3	26.1	24.0	11.1	28.1	6.11
1922	19.7	7.2	17.2	22.3	6.4	35.3	3.42
1923	49.3	12.5	16.1	41.7	23.9	12.2	.36
1924	47.3	(.83)	11.1	61.7	13.9	11.7	.83
1925	34.6	(1.25)	3.3	29.7	(2.67)	22.2	2.67

[1]Cowpeas. [2]Not harvested. [3]Oats; wheat destroyed by grasshoppers. [4]No record of yields; sweet clover plowed under. [5]Crop destroyed by grasshoppers. [6]Crop destroyed by fire.

crop, the straw and chaff being returned to the land. Limestone and bone meal have been used in both these rotations, and the crop residues have been returned to the land.

The annual crop yields of the two systems are recorded in Table 13, and a general summary of each is presented for comparison in Table 14.

The markerly higher production in all crops in the four-year rotation indicates the advantage of this system, in which one field out of four is devoted to the production of sweet clover, over the three-year system in which only catch crops of sweet clover are grown.

TABLE 14.—ODIN FIELD: USE OF SWEET CLOVER IN ROTATIONS
Average Annual Crop Yields 1906-1925—Bushels per acre

Rotation	Corn *20 crops*	Soybeans[1] *16 crops*	Wheat *19 crops*	Clover seed *11 crops*
Three-year	31.7	7.1	17.1	.....
Four-year	35.3	10.9	22.2	2.79

[1]Or cowpeas.

THE TOLEDO FIELD

The Toledo experiment field is located on Gray Silt Loam On Tight Clay immediately south of Toledo in Cumberland county. It was established in 1913. This field of 17 acres is laid out into two separate systems of plots, one including four series of 10 plots each, and the other containing four series of 4 plots each.

TABLE 15.—TOLEDO FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1914–1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *8 crops*	Corn *12 crops*	Oats *11 crops*	Clover[1] *4 crops*	Sweet clover *3 crops*	Soy-beans *3 crops*
1	0	8.5	22.2	16.5	(.06)	.11	(.70)
2	M	10.2	28.6	19.0	(.18)	.24	(.72)
3	ML	21.8	39.1	31.4	(.89)	2.45	(1.27)
4	MLrP	24.4	39.1	33.6	(.97)	2.42	(1.21)
5	0	8.1	18.3	15.6	(.05)	.26	3.8
6	R	9.5	19.8	17.1	(.24)	.53	4.7
7	RL	21.0	29.6	32.6	(1.19)	1.84	9.4
8	RLrP	24.3	30.8	35.2	(1.16)	1.77	10.5
9	RLrPK	26.8	41.0	38.4	(1.14)	2.48	11.8
10	0	5.3	15.7	16.9	(.17)	.23	(.53)

[1]Some seed evaluated as hay.

Series 100, 200, 300, 400

The system of plots made up of Series 100, 200, 300, and 400 is under a crop rotation of wheat, corn, oats, and clover. Cowpeas were seeded in the corn at the last cultivation until 1921, when this practice was abandoned. In 1922 sweet clover was introduced as the regular clover crop. At that time, after the plots had received a total of 6½ to 8 tons of limestone an acre on the different series, application of this material was suspended until further need for it becomes apparent. In 1923 the return of the wheat straw on the residues plots was discontinued.

Table 15 presents a summary of the crop yields including the years in which the complete plot treatments have been in effect. The results confirm those of other fields located on similar soil and, briefly stated, they show:

1. Low yields on untreated land.
2. Only a slight response to organic manures without limestone.
3. A very decided response to the use of limestone in connection with organic manures.
4. A limited response to rock phosphate applied with organic manures and limestone but not sufficient to cover the cost of material.
5. A rather general response to potassium fertilizer becoming very marked in the case of the corn.

Series 500, 600, 700, 800

The second set of plots on the Toledo field, comprizing Series 500, 600, 700, and 800, has been devoted mainly to an investigation in soil tillage, the purpose being to compare the effects of subsoiling, deep tilling, and dynamiting with that of ordinary plowing. A crop rotation of corn, soybeans, wheat, and sweet clover was adopted, second-year sweet-clover stubble being plowed late in the fall for corn. An application of 4 tons of limestone an acre was made on all plots in 1913; 3 tons were applied for the 1917 crop, and 2 tons for the 1921 crop. One ton of rock phosphate was applied in the fall of 1914, and again in the fall of 1918.

TABLE 16.—TOLEDO FIELD: TILLAGE EXPERIMENTS
Average Annual Yields 1913-1922—Bushels per acre

Tillage treatment	Corn *9 crops*	Soybeans *7 crops*	Wheat *6 crops*	Sweet-clover seed *6 crops*
Plowed 7 inches deep	40.2	16.3	13.5	3.68
Subsoiled 14 inches deep	41.9	16.2	12.9	3.65
Deep-tilled 14 inches	37.4	15.2	10.8	3.18
Dynamited	40.3	16.4	11.7	4.25

A summary of the crop yields is given in Table 16. For a detailed account of these experiments the reader is referred to Bulletin 258 of this Station, "Experiments with Subsoiling, Deep Tilling, and Dynamiting."

The conclusions reached from the results of these experiments is that none of the special tillage treatments had any beneficial effect on crop yields. Deep tilling apparently decreased yields, probably because of the mixing of subsurface and subsoil with the surface soil.

THE NEWTON FIELD

A 30-acre experiment field has been maintained by the University at Newton in Jasper county since 1912. The soil type has been mapped as Gray Silt Loam On Tight Clay but the field is not altogether uniform, as is shown by variations in the crop yields. The land is almost level. Drainage has been provided by a system of tile. Owing to the impervious nature of the subsoil, however, the tile did not materially improve the drainage until the scheme was devised of using the tiles as sewers to carry away the surplus water conducted to them thru a system of ditches and catch basins.

The field is laid off into 12 series of plots and these series make up four separate combinations or plot systems, only two of which will be considered here.

TABLE 17.—NEWTON FIELD: SERIES 100, 200, 300, SUMMARY OF CROP YIELDS
Average Annual Yields 1913–1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *10 crops*	Corn *13 crops*	Soybeans[1] *12 crops*
1	0	.5	10.7	5.6
2	M	.8	15.6	7.8
3	ML	8.8	24.7	11.7
4	MLrP	14.5	25.9	12.7
5	0	1.4	11.3	5.4
6	R	1.0	11.9	4.7
7	RL	7.6	18.0	8.1
8	RLrP	13.6	18.6	9.2
9	RLrPK	16.7	23.1	10.0
10	0	.2	7.3	5.2

[1]Some hay evaluated as seed.

Series 100, 200, 300

A rotation of corn, soybeans, and wheat has been practiced on Series 100, 200, and 300. Cowpeas have been seeded in the corn and sweet clover in the wheat as catch crops to help supply the organic matter and nitrogen on the residues plots. In 1920 the use of the cowpea catch crop was discontinued, as was also the return of wheat straw in 1922.

The limestone used on these series has been of the dolomitic form ground sufficiently fine to pass a 10-mesh sieve. The usual large initial amount of limestone was not applied here. Up to 1922 the different series had received 5 to 6 tons an acre, when the regular applications were suspended until further need for lime becomes apparent.

Table 17 gives a summary of the crop yields obtained, including the years that the respective, complete soil treatments have been in effect.

The results of these experiments are characteristic of those of other fields located on this soil type. They demonstrate once more the absolute necessity of liming as the foundation for soil improvement. Without lime, legumes fail completely and the use of manure alone is practically ineffective. Phosphorus in combination with lime and organic manure has, as usual, materially benefited the wheat but, in the manner used, the rock phosphate has not paid for itself. Some increase in yield of both wheat and corn has followed the use of potassium fertilizer, but the money value of this increase is not sufficient to cover the cost.

A profitable system of farming on this field must lie in other plans of cropping than that employed in these experiments, for even under the best treatment the plane of production is too low to represent a successful farming enterprise.

Special Limestone Experiments

After demonstrating the great value of limestone for soil improvement, especially in southern Illinois, a number of very practical questions immediately arose concerning details of its application as, for example: What is the most favorable amount to apply from various standpoints of economy? What degree of fineness of material is most suitable? Is magnesian or dolomitic limestone as effective as high-calcium stone? Is there any advantage in the use of burnt material over that of the raw crushed stone? To answer these questions a series of tests was started on Series 500 to 1000. The comparisons were arranged in the following manner.

The odd-numbered series (500, 700, 900) have received applications of high-calcium material, either crushed stone or burned, and the even-numbered series (600, 800, 1000) have received corresponding amounts of dolomitic material. On all series, Plots 2 to 6 have received limestone at the rate of 500 pounds an acre a year; Plots 8 to 12 have received 1,000 pounds; and Plots 13 to 18 have received 2,000 pounds. All applications were based upon the equivalent of pure calcium carbonate.

In addition to the lime on these plots, all have received rock phosphate and kainit in amounts and manner previously described. A crop rotation of corn, soybeans, and wheat was practiced until 1920, when it was changed to corn, wheat, and sweet clover. Since that time the wheat straw and sweet-clover chaff have

TABLE 18.—NEWTON FIELD: SPECIAL LIMESTONE TEST

Summary of Crop Yields 1913–1925—Bushels per acre

Serial plot No.	Fineness of grinding (meshes per inch)	Wheat *13 crops*		Corn *13 crops*		Soybeans *5 crops*		Sweet clover *6 crops*	
		High calcium	Dolomitic	High calcium	Dolomitic	High calcium	Dolomitic	High calcium	Dolomitic
1	No lime	7.5	9.0	11.3	10.8	3.4	3.8	0.00	0.00
	Applications of 500 pounds per acre per year to total of 3 tons per acre								
2	4 down	15.0	12.7	17.9	18.2	5.3	5.5	2.21	1.77
3	4 to 10	12.6	13.8	16.3	22.7	5.1	5.6	2.30	2.09
4	10 down	13.8	13.2	17.7	15.6	5.1	5.3	1.98	2.27
5	50 down	13.6	12.0	15.9	13.0	4.5	4.6	2.13	1.91
6	Burnt lime[1]	13.9	12.9	12.6	13.7	5.0	5.1	2.36	2.09
7	No lime	8.2	8.4	8.9	11.2	3.3	3.6	0.00	.10
	Applications of 1,000 pounds per acre per year to total of 6 tons per acre								
8	4 down	13.0	12.2	14.4	16.1	5.2	5.2	2.37	2.29
9	4 to 10	11.9	11.1	14.1	15.1	5.0	4.9	2.42	2.23
10	10 down	13.1	12.2	13.8	13.1	5.1	5.3	2.12	1.88
11	50 down	13.9	12.5	14.4	12.2	4.8	4.9	2.45	2.07
12	Burnt lime[1]	13.7	13.4	14.1	12.2	5.3	4.4	2.87	2.40
13	No lime	7.9	7.4	9.8	10.0	3.7	3.4	.37	.11
	Applications of 2,000 pounds per acre per year to total of 12 tons per acre								
14	4 down	14.4	14.2	17.9	15.3	6.1	5.7	3.37	2.55
15	4 to 10	12.8	13.9	17.6	18.2	5.4	5.1	3.29	2.10
16	10 down	16.2	15.6	17.5	18.0	5.4	5.9	3.31	2.27
17	50 down	17.6	17.4	17.0	16.8	6.7	6.1	3.00	2.51
18	Burnt lime[1]	17.8	18.2	18.9	19.8	6.4	6.6	3.19	2.99
19	No lime	8.3	8.8	12.9	14.1	3.0	3.4	.20	.16

[1]Purchased as burnt lime, but applied after hydrating or slaking.

been returned to the land; the cornstalks have been removed. In 1922 limestone was evened up to a uniform total amount of 3 tons an acre on the plots receiving light applications, to 6 tons an acre on plots receiving medium applications, and to 12 tons on plots receiving heavy applications. No more lime will be applied until an apparent need for it develops.

A summary of the crop yields including the years since the complete plot treatments have been under way is shown in Table 18. In order to study the relative economy of the various amounts and kinds of lime applied, the value of the respective crop yields have been calculated and these are shown in Table 19, along with the value of the corresponding increases due to treatment. Using these figures as a basis, the value of a ton of limestone has also been calculated, and finally the returns per dollar invested in the different forms and amounts of lime are included in this table.

In considering the results it is to be noted that the subsoil on this field is not altogether uniform with respect to acidity. Spots have been found in which carbonates exist. Therefore definite conclusions are probably warranted only on the more outstanding differences. Without going into a fine analysis of the data, the following facts appear from scanning the figures of these tables:

Amount of Lime.—Considered from the standpoint of total production, the heavy applications produced the greatest yield, altho the light applications produced somewhat higher yields than the medium. If, however, the profitableness of the practice be considered from the standpoint of value per ton of material applied, the law of diminishing returns becomes operative, making the value per ton two or three times as much in the light application as that in the heavy application. The effect is magnified in the returns per dollar invested. The figures show about $12 to $17 return for the light applications as compared with about $4 return per dollar invested in the heavy applications. Presumably the residual effect will be greater with the heavy application which, in the course of time, will compensate to some extent for the smaller profit thus far obtained.

Fineness of Material.—Aside from a possible slight tendency in the heavy application toward higher production from finer grinding, there seem to be no very well-defined differences with respect to fineness of grinding. The practical conclusion therefore is that there is little or no advantage to be gained in reducing the stone completely to a powder.

High-Calcium Compared with Dolomitic Material.—The figures showing value of annual increase indicate a certain tendency in favor of the high-calcium over the dolomitic material. Some of the differences, however, are rather small and there are among the fifteen possible comparisons three exceptions. Altho

TABLE 19.—NEWTON FIELD: SPECIAL LIMESTONE TEST, FINANCIAL COMPARISONS[1]

Serial plot No.	Fineness of grinding (meshes per inch)	Average annual acre value of crops		Value of annual increase for lime		Value of one ton of limestone[2]		Returns per dollar invested	
		High calcium	Dolomitic	High calcium	Dolomitic	High calcium	Dolomitic	High calcium	Dolomitic
1	No lime....	$7.86	$8.64	....	....	....	....	....	....
	Applications of limestone: 500 pounds per acre per year to a total of 3 tons								
2	4 down....	$16.91	$15.02	$9.13	$6.51	$39.52	$28.18	$19.76	$14.09
3	4 to 10....	15.29	17.20	7.51	8.69	32.51	37.62	16.26	18.81
4	10 down...	15.97	15.24	8.19	6.73	35.45	29.13	17.73	14.57
5	50 down...	15.43	13.30	7.65	4.79	33.12	20.74	16.56	10.37
6	Burnt lime.	15.11	14.37	7.33	5.86	31.73	25.37	4.00	3.24
7	No lime....	$7.70	$8.38	....	....	....	....	....	....
	Applications of limestone: 1,000 pounds per acre per year to a total of 6 tons								
8	4 down....	$15.25	$14.92	$6.72	$6.97	$14.55	$15.09	$7.68	$7.55
9	4 to 10....	14.56	13.92	6.03	5.97	13.05	12.90	6.53	6.45
10	10 down...	14.77	13.56	6.24	5.61	13.51	12.14	6.76	6.07
11	50 down...	15.61	13.64	7.08	5.69	15.32	12.32	7.66	6.61
12	Burnt lime.	16.02	14.44	7.49	6.49	16.21	14.05	2.07	1.79
13	No lime....	$9.36	$7.51	....	....	....	....	....	....
	Applications of limestone: 2,000 pounds per acre per year to a total of 12 tons								
14	4 down....	$18.27	$16.17	$9.27	$7.71	$10.04	$8.35	$5.02	$4.18
15	4 to 10....	17.15	16.07	8.15	7.61	8.83	8.24	4.42	4.12
16	10 down...	18.81	17.32	9.81	8.86	10.63	9.60	5.32	4.80
17	50 down...	19.23	18.21	10.23	9.75	11.08	10.56	5.54	5.28
18	Burnt lime.	19.54	20.16	10.54	11.70	11.42	12.68	1.42	1.48
19	No lime....	$8.63	$9.40	....	....	....	....	....	....

[1]Based upon the following prices: wheat, $1.50 per bushel; corn, 75 cents; soybeans, $1.50; sweet clover, $7.50; crushed limestone, $2 a ton; burnt lime, $14 a ton..

[2]Or its equivalent in burnt lime.

this trend is of interest, the experiments are not sufficiently extended to warrant without further evidence a discrimination between the two kinds of stone. In the purchase of limestone there is another consideration to bear in mind, and that is the possible need of the soil for magnesium, which element is furnished in dolomitic stone. For further discussion of this phase of the problem, see Appendix, page 32.

Burnt Lime Compared with Ground Limestone.—It may be explained that the term "burnt limestone" is used here to comply with the previous records. As a matter of fact, the material was purchased as burnt lime but it was hydrated or slaked before being applied to the soil.

In the light application the burnt material appears to be slightly less effective than the average of the crushed grades, both in the high-calcium and in the dolomitic products. In the medium and heavy applications, however, the reverse

FIG. 5.—WITHOUT LIMESTONE SWEET CLOVER REFUSES TO GROW
At the right where no clover is seen, no limestone has been applied.

is true, altho in no case is the difference great. In the value of a ton of limestone the figures follow the same order.

The most striking comparison is found in the returns per dollar invested, owing of course to the high cost of the burnt material. In these estimates the local dealers' present market price of $14 a ton in carload lots is allowed with no consideration of the extra trouble in preparing it for application by slaking. In the light application the returns on a dollar invested for high-calcium burnt lime is $4, while for the corresponding crushed stone it is $17.58. In the heavy applications the corresponding figures are $1.42 and $5.08 respectively. The figures for the dolomitic material are in about the same order.

From these results it appears that the answer to the question whether to use burnt lime or ground limestone will depend, not upon the relative effectiveness of the two in the soil, but rather upon the economy of their application. Only under exceptional circumstance would burnt lime compete with ground limestone. Such a situation might be one in which crushed limestone is not readily accessible

and burnt lime could be produced very cheaply; or for gardening, where only small quantities are required, burnt lime may be procured wherever building supplies are sold.

THE DUBOIS FIELD

Another experiment field on Gray Silt Loam On Tight Clay is located at DuBois in Washington county. This land lies practically level and appears to be uniform in soil type. The experiments were started in 1902. The field was laid off into a single series of plots having two sections, one tiled and the other untiled.

The rotation practiced the first eight years was corn, oats, and wheat followed by a legume. After two of these rotations the order was changed to corn, oats, clover, wheat, with a seeding of sweet clover and alsike on the residues plots for use as a green manure. Since there appeared to be little difference between the tiled and untiled sections, another change in cropping was made in 1922 by which corn is grown on one section and wheat with a seeding of sweet clover on the other.

Five tons of hydrated lime an acre was applied in 1902, and no further application of lime was made until 1922, when 2 tons of limestone an acre was applied on the east section and 1,000 pounds an acre on the west section.

Until 1905 nitrogen was applied annually in approximately 650 pounds of dried blood an acre on what are now the residues plots; thereafter crop residues were substituted. Phosphorus was supplied in form of steamed bone meal applied at the rate of 200 pounds an acre a year, and potassium in 100 pounds of potassium sulfate an acre a year. In 1922 the applications of both phosphorus and potassium were discontinued temporarily.

A general summary of the annual crop yields is assembled in Table 20, and for convenience in studying the effect of the treatments the various possible comparisons are brought together in Table 21, where the results of the corresponding plots of the two sections are averaged and expressed in terms of crop increases. Some points of interests brought out by these comparisons are the following:

Altho *lime,* as used in these experiments, has produced some increase in all crops, when applied alone it does not raise the plane of production sufficiently to give a profitable system of farming. In the presence of other fertilizing materials, however, its effectiveness is greatly enhanced.

The response to *residues* in the various combinations is rather complex. In some cases the increases to be ascribed to residues are marked. In the treatment with lime, phosphorus, and potassium, the effect of residues on the grain crops is quite indifferent, while on the hay crop it is very pronounced. In considering these residues results it should be noted that they include the data of the earlier years, when dried blood was used instead of residues to furnish nitrogen.

Phosphorus has given increases in all combinations in all crops, but the most significant effect produced has been on the wheat. *Potassium* has produced a remarkable effect on the corn; in some cases the yields have been practically doubled following the potassium treatment.

TABLE 20.—DUBOIS FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1902–1923—Bushels or (tons) per acre

Plot No.[1]	Soil treatment applied[2]	Wheat *6 crops*	Corn *6 crops*	Oats *5 crops*	Clover Hay *4 crops*	Clover Seed *2 crops*	Soybeans *1 crop*
1	0	5.4	10.8	14.0	(.58)	.....	3.5
2	L	9.7	13.0	23.0	(.61)	.....	6.7
3	LR	13.6	17.6	30.8	(.89)[3]	.80	7.2
4	LP	20.7	17.1	35.2	(1.04)	.....	8.5
5	LK	16.7	25.9	30.8	(.89)	.....	9.3
6	LRP	26.5	17.5	33.8	(1.17)[3]	1.88	8.2
7	LRK	19.7	25.2	32.9	(1.74)[3]	2.38	7.8
8	LPK	28.0	29.1	37.6	(1.67)	.....	9.5
9	LRPK	27.0	28.8	34.8	(2.22)[3]	2.09	7.8
10	RPK	18.9	22.1	26.5	(2.00)[3]	2.09	6.3
11	0	6.3	11.7	14.3	(.54)	.....	3.3
12	L	13.6	13.8	22.5	(.77)	.....	6.2
13	LR	16.2	16.4	28.0	(1.33)[3]	1.33	6.7
14	LP	22.2	13.3	32.4	(1.14)	.....	7.2
15	LK	16.1	25.2	33.8	(1.23)	.....	7.8
16	LRP	27.0	18.3	38.1	(2.11)[3]	2.42	8.8
17	LRK	23.3	29.7	32.4	(2.19)[3]	2.04	10.2
18	LPK	30.0	32.4	34.8	(1.88)	.....	10.3
19	LRPK	28.0	30.8	33.1	(2.67)[3]	2.08	11.3
20	RPK	18.8	21.8	30.2	(2.41)[3]	2.25	6.7

[1]Plots 1 to 10 not tiled. Plots 11 to 20 tiled.
[2]Until 1905 dried blood was applied instead of residues.
[3]Only two crops of hay on Plots 3, 5, 7, 9, 10, 13, 16, 17, 19, and 20.

TABLE 21.—DUBOIS FIELD: EFFECT OF TREATMENTS IN TERMS OF ANNUAL CROP INCREASES

Bushels or (tons) per acre

Comparison of treatments	Wheat *6 crops*	Corn *6 crops*	Oats *5 crops*	Clover hay[1] *2 or 4 crops*	Soybeans *1 crop*
Lime					
L over 0	5.8	2.2	8.6	(.13)	3.1
LRPK over RPK	8.7	7.9	5.6	(.24)	3.1
Residues					
LR over L	3.3	3.6	6.7	(.42)	.5
LRP over LP	5.3	2.7	2.2	(.55)	.7
LRK over LK	5.1	1.9	.4	(.91)	.5
LRPK over LPK	−1.5	−1.0	−2.3	(.67)	−.4
Phosphorus					
LP over L	9.8	1.8	11.1	(.40)	1.4
LRP over LR	11.9	.9	6.6	(.53)	1.6
LPK over LK	12.6	5.2	3.9	(.72)	1.4
LRPK over LRK	6.0	2.4	1.3	(.48)	.6
Potassium					
LK over L	4.8	12.2	9.6	(.37)	2.1
LRK over LR	6.6	10.5	3.3	(.86)	2.1
LPK over LP	7.6	15.6	2.4	(.69)	2.1
LRPK over LRP	.8	11.9	−2.0	(.81)	1.1

[1]Omitting any consideration of clover seed produced on certain plots.

These results in general confirm those of the other fields located on the same soil type, in that wheat responds in a notable way to phosphorus treatment while corn receives its greatest benefit from potassium treatment. A rational system of general farming designed to bring this land into the highest production of which it is capable calls for the application of both these elements of plant food to be used in conjunction with limestone and organic manures.

The marked benefit to wheat and the indifferent response of all other crops following the use of bone meal suggest that in practice perhaps phosphorus could be supplied more economically by using somewhat smaller quantities of phosphatic fertilizer and applying it directly to the wheat crop. Likewise, it seems probable, judging from the relative crop responses to potassium treatment, that the expense of potassium fertilizer might be reduced by cutting down the quantity used in these tests, applying the material direct to the corn crop. The organic manures are well furnished by crop residues and legumes plowed down but, under some circumstances, at least a part of the legumes and crop residues will be utilized advantageously by pasturing or feeding them to livestock, the manure produced therefrom to be carefully conserved and regularly returned to the land.

THE EWING FIELD

As representing the soil type Gray Silt Loam On Orange-Mottled Tight Clay, experimental results from a portion of the Ewing field are presented.

The Ewing field is located in Franklin county about a mile northeast of Ewing. It was established in 1910. Altho four distinguishable soil types have been identified on this field, the 100 and 200 series of plots lie wholly on Gray Silt Loam On Orange-Mottled Tight Clay. This land is nearly level, the drainage is very poor, and the soil is strongly acid. These two series, together with Series 300 and 400, constitute a plot system farmed under a crop rotation of wheat, corn, oats, and clover, but because Series 300 and 400 lie mainly on another soil type, results from these plots will not enter into the present consideration.

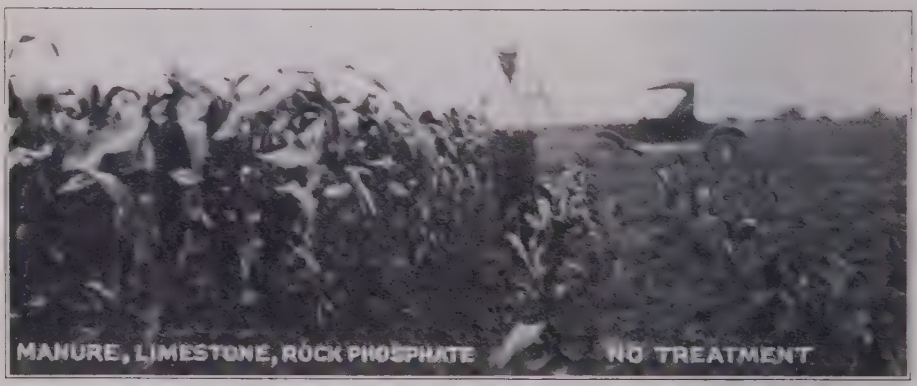

FIG. 6.—CORN GROWING ON NEIGHBORING PLOTS ON THE EWING FIELD IN 1924

At the right is a check plot which has produced, as an average of eight years, only 15 bushels of corn an acre; while at the left the plot treated with manure, limestone, and rock phosphate has produced 49 bushels an acre as an average for this same period.

The handling of the crops and the soil treatments have been in the main according to the somewhat standard plan described above. Until 1920 cowpeas were seeded in the corn as a catch crop on the residues plot. In 1921 sweet clover was substituted as the regular legume in the rotation in addition to its seeding in the wheat for use as a green manure crop. Seed was harvested from all the regular sweet-clover plots and the straw returned to the residues plots. In 1922 the limestone applications were discontinued after they had reached a total quantity of 8½ to 10 tons an acre on the different series. No more limestone will be applied until the need for it appears. The return of the wheat straw as a residue was also discontinued at that time. In 1923 the rock phosphate was evened up on all phosphorus plots to 8,500 pounds an acre, and no more will be applied for an indefinite period.

TABLE 22.—EWING FIELD: SERIES 100 and 200, SUMMARY OF CROP YIELDS

Average Annual Yields 1911–1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *6 crops*	Corn *8 crops*	Oats *8 crops*	Clover *2 crops*	Soybeans *3 crops*	Sweet clover *2 crops*
1	0	2.2	15.3	9.8	(.26)	(.36)	0.00
2	M	4.1	30.6	15.4	(.31)	(.42)	0.00
3	ML	14.8	47.8	29.0	(.91)	(.89)	2.23
4	MLrP	20.0	49.0	31.0	(1.12)	(1.02)	2.25
5	0	2.2	14.9	9.4	(.19)	1.8	0.00
6	R	1.7	15.2	9.9	(.23)	1.8	0.00
7	RL	15.9	33.2	26.2	(.87)	6.1	2.46
8	RLrP	19.0	31.7	27.2	(1.15)	7.2	2.07
9	RLrPK	26.1	47.3	34.9	(1.06)	8.5	2.08
10	0	3.3	20.1	10.9	(.37)	(.42)	0.00

A summary of the results is presented in Table 22, showing the average annual crop yields obtained for the years the plots have been under their complete treatments. The extremely poor yields on the untreated land testify to the natural poverty of this soil. About 2.5 bushels of wheat an acre has been the average production on the check plots.

The use of manure alone increases the crop yields somewhat, but not sufficiently to put this kind of farming on a profitable basis. Residues alone are practically without effect.

Limestone produces a very decided increase in yields used either with manure or with residues, the large increase with the latter being due mainly to the successful growth of legumes following the application of limestone.

Rock phosphate has produced a substantial increase in the yield of wheat, but it has had little or no significant effect on other crops. Used in the quantity applied in these experiments, the profits on the wheat would scarcely carry the cost of material. As explained above, however, the phosphate applications have been suspended to observe the residual effect. The results of the next few years should furnish new light on the economy in the use of phosphate on this soil.

Potassium fertilizer, as used in these experiments, has had a decidedly beneficial effect on all the grain crops.

The response to treatment on this field resembles in general that on the group of fields discussed above. The suggestions, therefore, for the practical improvement of this soil type correspond to those for Gray Silt Loam On Tight Clay.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT NO. 35

WILL COUNTY SOILS

By R. S. SMITH, O. I. ELLIS, E. E. DeTURK, F. C. BAUER, and L. H. SMITH

UNIVERSITY OF ILLINOIS LIBRARY

URBANA, ILLINOIS, DECEMBER, 1926

The Soil Survey of Illinois was organized under the general supervision of Professon Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Will county was conducted.

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WILL COUNTY SOILS

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WILL COUNTY SOILS

By R. S. SMITH, O. I. ELLIS, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

LOCATION AND CLIMATE OF WILL COUNTY

Will county is situated in the northeastern part of Illinois, about 22 miles south and west of Lake Michigan. The county is irregular in outline and comprizes an area of about 834 square miles. It is located entirely within the area covered by the late Wisconsin glaciation. One hundred forty square miles lie in the Kankakee-DesPlaines terrace.

The climate of Will county has a fairly wide range of temperature between the extremes of winter and summer. The greatest range for any one year in the thirty-year period from 1895 to 1924 was 126 degrees in 1914. The highest temperature recorded during this period was 104°; the lowest, 25° below zero. During this thirty-year period, the temperature reached zero, or below, every winter with the exception of three, those of 1906, 1908, and 1921. During this same period, the winter temperature fell to 10° or more below zero in twenty out of the thirty winters, and the summer temperature registered 100° or more during fifteen summers. The average date of the last killing frost in the spring is May 2, the earliest in the fall, October 10, which gives an average growing season of 161 days.

The average annual rainfall for Will county for the thirty-year period was 32.83 inches. The average rainfall by months for this period was as follows: January, 1.90 inches; February, 1.57; March, 2.73; April, 2.66; May, 3.80; June, 3.44; July, 3.35; August, 3.37; September, 3.56; October, 2.37; November, 2.05; December, 1.90.

AGRICULTURAL PRODUCTION

Will county is agricultural in its interests. It is well adapted to grain, livestock, dairy, or mixed farming because of its large proportion of dark-colored upland soil and because of the nearness of the Chicago and other markets. The dairy industry is centered around Joliet, New Lenox, Mokena, Lockport, and Steger. Nearly all the milk is shipped or hauled directly into Chicago and Joliet. There are very few creameries and cheese factories in the county, and no livestock centers. Beef cattle and hogs are important, but only a very few sheep are found on the farms.

According to the Fourteenth Census of the United States, there were 3,385 farms in Will county in 1919. These had an average of 144.2 acres, of which 127.3 acres were improved. Approximately 90 percent of the county is in farm land. During the past ten years there has been a slight decrease in the number of farms and an increase in tenantry.

---

[1] R. S. Smith, in charge of soil survey mapping; O. I. Ellis, Assistant Chief in soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

The principal crops grown are wheat, corn, oats, barley, rye, forage, and hay. The acreage in alfalfa and sweet clover has gradually increased since 1920. The Census reports the following acreage and yield of the principal crops for 1919.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	129,404	4,271,101 bu.	32.2 bushels
Oats	112,028	3,790,775 bu.	33.8 bushels
Wheat	54,175	954,452 bu.	17.6 bushels
Barley	6,281	161,560 bu.	25.7 bushels
Rye	4,175	54,345 bu.	13.0 bushels
Timothy	20,761	24,937 tons	1.20 tons
Timothy and clover mixed	17,727	21,150 tons	1.20 tons
Clover	3,312	4,031 tons	1.21 tons
Alfalfa	1,984	5,113 tons	2.57 tons
Silage crops	11,235	64,968 tons	5.78 tons
Corn for forage	21,700	25,868 tons	1.19 tons

These figures are for but a single year. For the ten-year period 1911 to 1920 the U. S. Department of Agriculture gives the average yield of corn as 35.6 bushels; oats, 40.6 bushels; winter wheat, 20.2 bushels; hay, 1.19 tons.

The importance of livestock in the agriculture of Will county is shown by the following figures for 1919, also taken from the Census of 1920:

Animals and Animal Products	*Number*	*Value*
Horses	21,197	$1,967,586
Mules	468	54,805
Beef cattle	13,313	1,219,584
Dairy cattle	30,574	2,124,790
Sheep	3,196	37,481
Swine	47,262	972,718
Value of all poultry	.....	392,686
Value of eggs and chickens	.....	942,175
Value of dairy products	.....	1,472,625
Wool	12,994 lbs.	6,774

Fruit and vegetable growing in Will county have been, until recently, limited to small garden patches and orchards for home consumption. However, in the territory adjacent to or near the industrial centers of Joliet, Steger, and Chicago Heights, truck gardening has been on a rapid increase since 1920. Grape growing in the sandy region near Braidwood and Wilmington, formerly a coal mining section, has been on an increase during recent years. Melons also are grown extensively in this region.

Limestone, phosphates, and mixed fertilizers are used extensively in the county. The truck gardeners make liberal use of manure and other fertilizers.

SOIL FORMATION

GLACIATION

One of the most important periods in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during which and immediately following, the material that later formed the mineral portion of the soils was being deposited.

During the Glacial period, three ice sheets, the Illinoisan, early Wisconsin, and late Wisconsin, advanced across the area now occupied by Will county. The last of these great ice advances, the late Wisconsin, built up an extensive system of moraines known as the Valparaiso morainic system, which is concentric to Lake Michigan. The morainic ridge which occurs along the west side of the

SOIL

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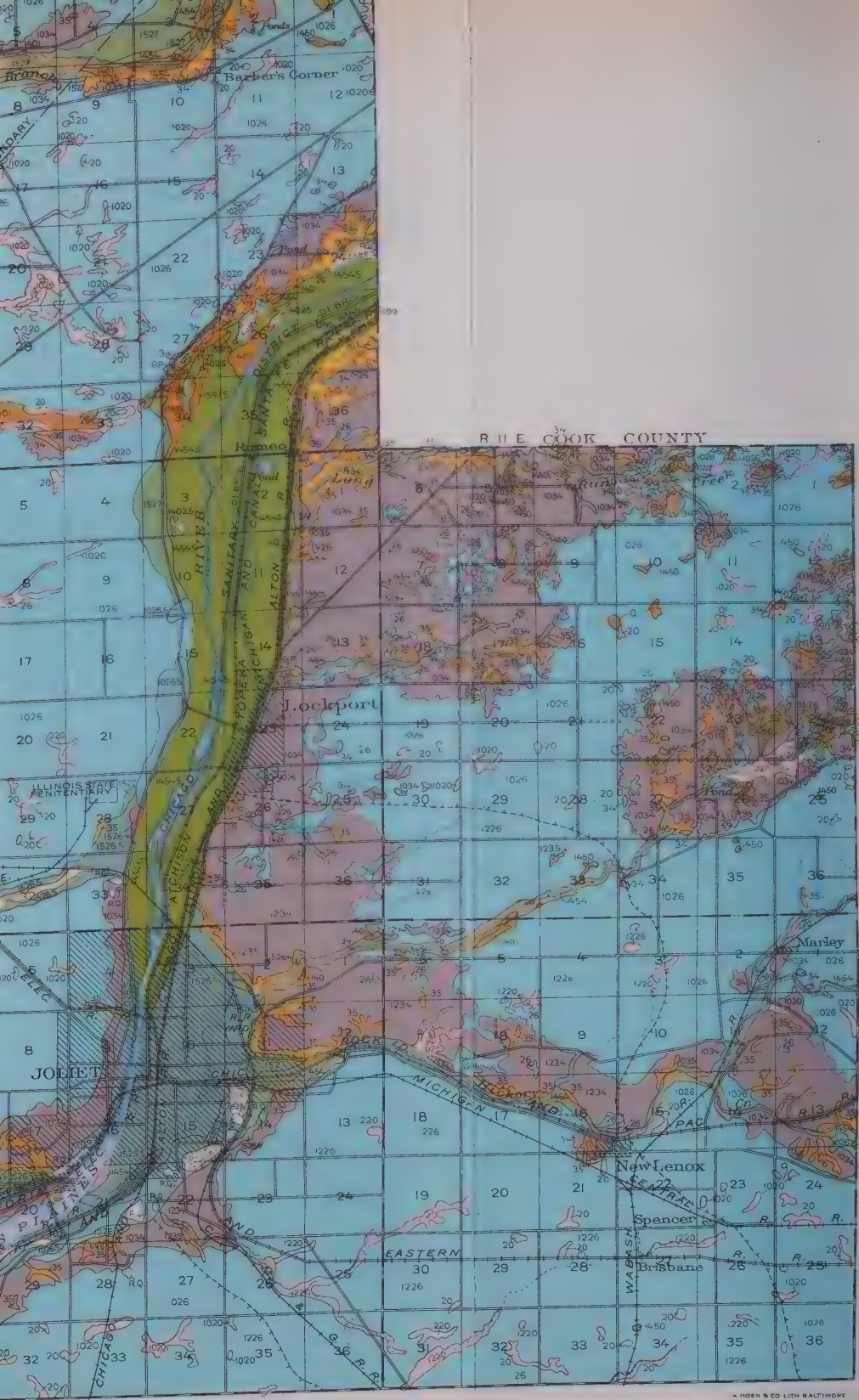


RVEY MAP OF WILL COUNTY

NOIS AGRICULTURAL EXPERIMENT STATION

county is known as the Minooka ridge. The peculiar topography, known as knob-and-basin topography, which occurs in the northern part of the county, is characteristic of the late Wisconsin moraines.

The thickness of the glacial drift varies from a few feet to 150 feet or more. Probably very little of the surface soil is derived from the underlying drift, since it was covered by a blanket of wind-blown material, or loess. The loess averages about 35 inches in thickness, varying from about 16 inches to 4 or 5 feet.

SOIL DEVELOPMENT

During the time which has elapsed since the last ice invasion, weathering and other processes have been active, resulting in the formation of the soils of the county as we know them today. Since the upland prairie has been occupied, probably continuously, by grass vegetation, organic matter has accumulated, resulting in the formation of productive, dark-colored soils. The agencies of weathering, acting on the soil material, caused the leaching of certain minerals, the accumulation of others, and the movement of particles into layers, zones, or "horizons." Thus, we now have distinct horizons in the upland soils which are designated by the letters A, B, and C. The areas adjacent to streams, which have been occupied by timber, are light-colored because of relative deficiency of the surface soil in organic matter. The bottom-land soils are made up, for the most part, of alluvial material brought down from the uplands of the immediate vicinity. These soils are immature and have not developed horizons, as is the case with the mature upland soils.

PHYSIOGRAPHY AND DRAINAGE

Will county presents striking variations in topography. The upland varies from flat to rolling. In the northern part of the county, adjacent to DuPage and Cook counties, the topography is of the knob-and-basin type, as previously noted. The terraces, which are located principally in the western and southwestern part of the county, vary from flat to undulating. In the portion which borders the Kankakee river, the rolling topography is due to the action of the wind upon the sandy soils, piling them into dune-like formations.

Will county has four distinct drainage basins, namely: Lake Michigan, Kankakee, DesPlaines, and DuPage. The drainage map, page 4, shows the portions of the county within each of these basins. DesPlaines and Kankakee rivers pass thru extensive terraces and old swamp areas, converging one mile west of the Grundy-Will county line to form Illinois river. Will county forms a part of the divide between the Mississippi and St. Lawrence river basins. Since the opening of the Chicago Sanitary District canal in 1900, part of the waters of Lake Michigan have been diverted thru the canal into DesPlaines river at Lockport.

The rivers of the county rarely overflow their banks during periods of high water because of their wide and deep channels. The upland areas of the county are, for the most part, well drained by tile, open ditches, intermittent streams, and creeks. The terraces that are underlain with coarse sand and

FIG. 1.—DRAINAGE MAP OF WILL COUNTY SHOWING STREAM COURSES AND TERRACE, BOTTOM-LAND, MORAINAL, AND INTERMORAINAL AREAS

gravel have good drainage, while those that are underlain with finer-grained sand and limestone are usually insufficiently drained.

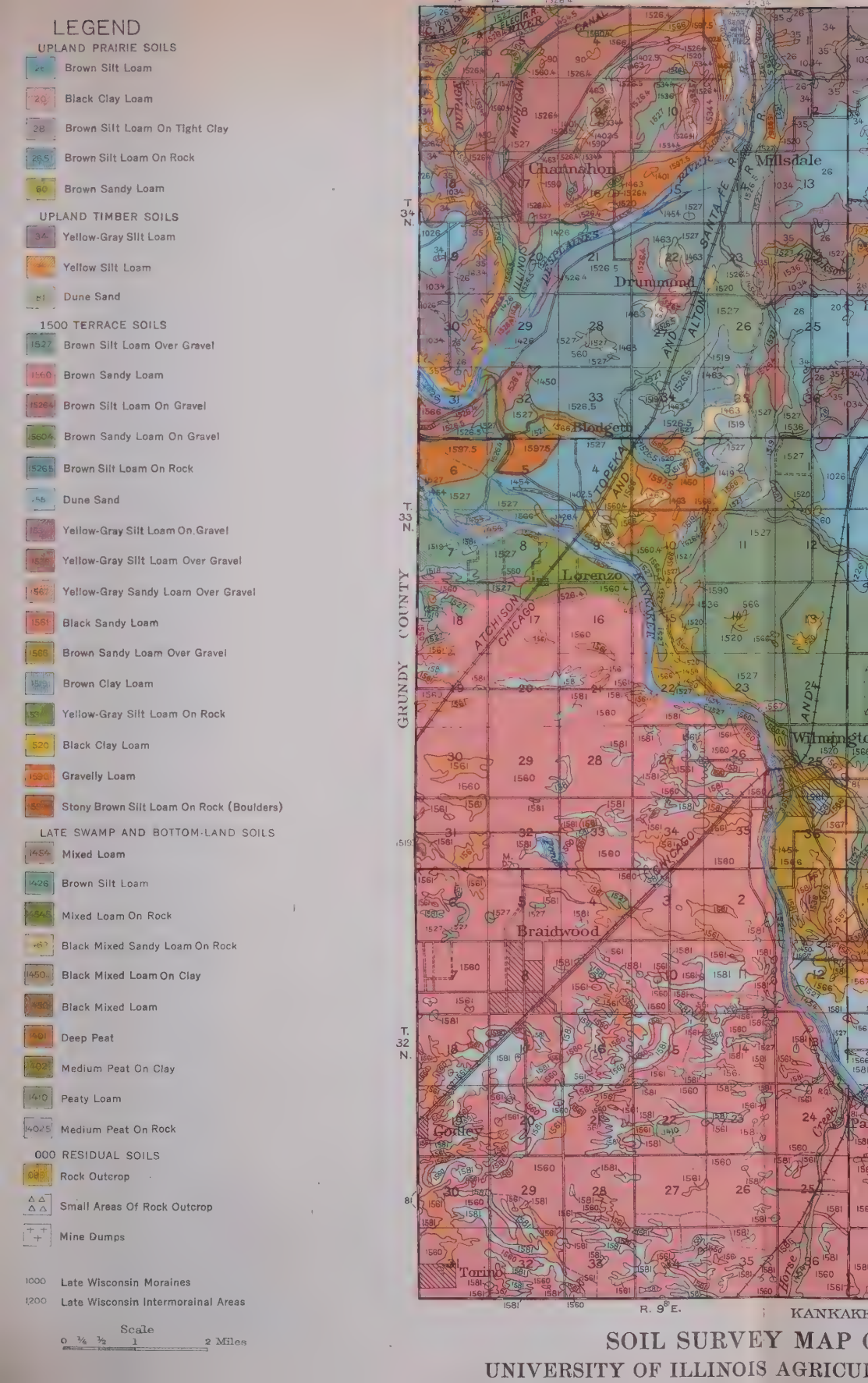
The altitudes of some of the locations in Will county are as follows: Beecher, 720 feet; Frankfort, 764; Joliet, 539; Manhattan, 686; Monee, 800; Wilmington, 549.

SOIL GROUPS

The soils of Will county are divided into four groups, as follows:

Upland Prairie Soils, usually rich in organic matter. These areas were originally covered with wild prairie grasses, the partially decayed roots of which have been the chief source of the organic matter.

Upland Timber Soils, including those soils often found along stream courses on which forests grew for a long period of time. These soils contain less organic matter than the prairie soils because the large roots of dead trees


LEGEND
UPLAND PRAIRIE SOILS
Brown Silt Loam
Black Clay Loam
Brown Silt Loam On Tight Clay
Brown Silt Loam On Rock
Brown Sandy Loam
UPLAND TIMBER SOILS
Yellow-Gray Silt Loam
Yellow Silt Loam
Dune Sand
1500 TERRACE SOILS
Brown Silt Loam Over Gravel
Brown Sandy Loam
Brown Silt Loam On Gravel
Brown Sandy Loam On Gravel
Brown Silt Loam On Rock
Dune Sand
Yellow-Gray Silt Loam On Gravel
Yellow-Gray Silt Loam Over Gravel
Yellow-Gray Sandy Loam Over Gravel
Black Sandy Loam
Brown Sandy Loam Over Gravel
Brown Clay Loam
Yellow-Gray Silt Loam On Rock
Black Clay Loam
Gravelly Loam
Stony Brown Silt Loam On Rock (Boulders)
LATE SWAMP AND BOTTOM-LAND SOILS
Mixed Loam
Brown Silt Loam
Mixed Loam On Rock
Black Mixed Sandy Loam On Rock
Black Mixed Loam On Clay
Black Mixed Loam
Deep Peat
Medium Peat On Clay
Peaty Loam
Medium Peat On Rock
000 RESIDUAL SOILS
Rock Outcrop
Small Areas Of Rock Outcrop
Mine Dumps
1000 Late Wisconsin Moraines
1200 Late Wisconsin Intermorainal Areas
Scale
0 ¼ ½ 1 2 Miles
Chatsahon
Millsdale
Drummond
Blodgett
Lorenzo
Braidwood
Godley
Torino
Wilmington
GRUNDY COUNTY
T. 34 N.
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SOIL SURVEY MAP
UNIVERSITY OF ILLINOIS AGRICUL

A. HOEN & CO. LITH. BALTIMORE

OUNTY

ILL COUNTY

L EXPERIMENT STATION

and the surface accumulation of leaves, twigs, and fallen trees decayed almost completely or were burned by forest fires.

Terrace Soils, formed from deposits laid down by flooded streams during high water at the time of the melting of the glaciers. Large quantities of sand deposited on certain portions of the terrace have been reworked by the wind. These areas constitute the sand dunes in Will county.

Swamp and Bottom-Land Soils, including the overflow land or flood plains along streams, the swamps, and the poorly drained lowlands.

Table 1 gives a list of the soil types found in Will county, the area of each type, and its percentage of the total area. The accompanying map shows the location and boundary of each type of soil down to areas of only a few acres in extent. For explanations concerning the classification of soils and the interpretation of the maps and tables, the reader is referred to the first part of the Appendix to this report.

TABLE 1.—SOIL TYPES OF WILL COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils (1000, 1200)			
1026, 1226	Brown Silt Loam	544.46	348 454	65.22
1020, 1220	Black Clay Loam	23.75	15 200	2.84
1028.1, 1228.1	Brown Silt Loam On Tight Clay	.84	538	.10
1026.5	Brown Silt Loam On Rock	2.21	1 414	.26
1060, 1260	Brown Sandy Loam	.12	77	.02
		571.38	365 683	68.44
	Upland Timber Soils (1000, 1200)			
1034, 1234	Yellow-Gray Silt Loam	61.92	39 629	7.42
1035, 1235	Yellow Silt Loam	6.96	4 454	.83
1081	Dune Sand	.22	141	.03
		69.10	44 224	8.28
	Terrace Soils (1500)			
1527	Brown Silt Loam Over Gravel	29.19	18 682	3.50
1560	Brown Sandy Loam	46.26	29 606	5.54
1526.4	Brown Silt Loam On Gravel	18.29	11 706	2.19
1560.4	Brown Sandy Loam On Gravel	1.65	1 056	.20
1526.5	Brown Silt Loam On Rock	17.11	10 950	2.05
1581	Dune Sand	7.16	4 582	.86
1534.4	Yellow-Gray Silt Loam On Gravel	2.36	1 510	.28
1536	Yellow-Gray Silt Loam Over Gravel	1.94	1 242	.23
1567	Yellow-Gray Sandy Loam Over Gravel	2.32	1 485	.28
1561	Black Sandy Loam	5.58	3 571	.67
1566	Brown Sandy Loam Over Gravel	4.34	2 778	.52
1519	Brown Clay Loam	1.23	787	.15
1534.5	Yellow-Gray Silt Loam On Rock	.02	13	.002
1520	Black Clay Loam	1.67	1 069	.20
1590	Gravelly Loam	.05	32	.005
1597.5	Stony Brown Silt Loam On Rock (boulders)	3.17	2 029	.38
		142.34	91 098	17.05

TABLE 1.—SOIL TYPES OF WILL COUNTY, ILLINOIS—*Continued*

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Late Swamp and Bottom-Land Soils (1400)			
1454	Mixed Loam	19.56	12 518	2.34
1426	Brown Silt Loam	2.38	1 523	.28
1454.5	Mixed Loam On Rock	9.14	5 850	1.09
1463	Black Mixed Sandy Loam On Rock	2.66	1 702	.32
1450.1	Black Mixed Loam On Clay	.86	551	.10
1450	Black Mixed Loam	5.16	3 302	.62
1401	Deep Peat	2.06	1 318	.24
1402	Medium Peat On Clay	.10	64	.02
1410	Peaty Loam	.11	71	.02
1402.5	Medium Peat On Rock	.05	32	.005
		42.08	26 931	5.03
	Residual Soils (000)			
099	Rock Outcrop	.25	160	.03
	Miscellaneous			
	Rock quarry	.71	454	.09
	Gravel pit	.87	557	.10
	Water	8.06	5 158	.97
	Mine dump	.07	45	.01
		9.71	6 214	1.17
	Total	834.86	534 310	100.00

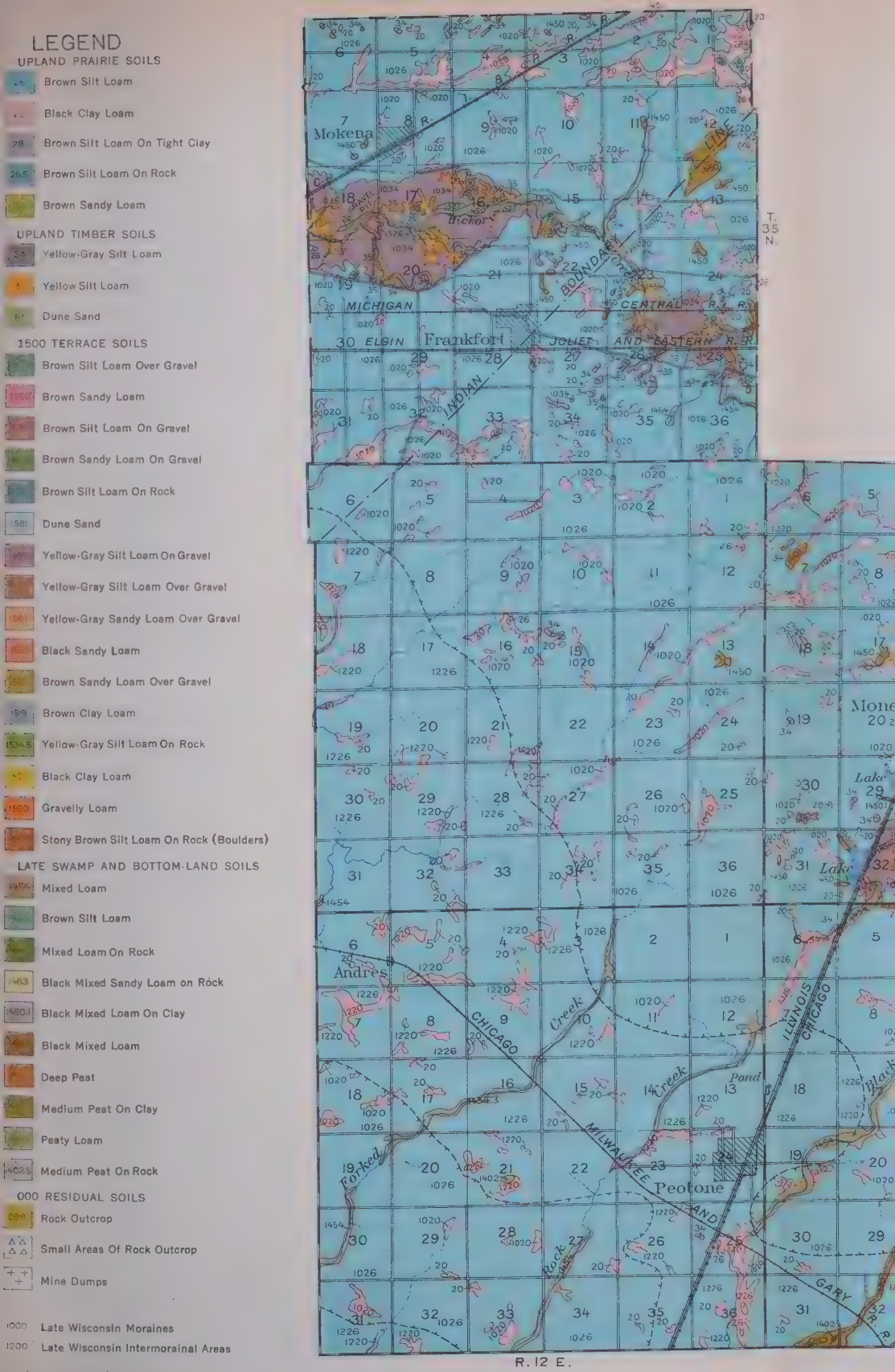
INVOICE OF THE ELEMENTS OF PLANT FOOD IN WILL COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described in the following paragraph and subjected to chemical analysis for its important plant-food elements.

Samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (extending from 0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches) and a lower stratum (20 to 40 inches). These sampling strata correspond approximately in the common kinds of soil to 2 million pounds an acre of dry soil in the upper stratum, to two times this quantity in the middle stratum, and to three times it in the lower stratum. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil.

By this system of sampling we have represented separately three zones for plant feeding. The upper, or surface layer, includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials, actually



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IS AGRICULTURAL EXPERIMENT STATION

present in the soil strata sampled and analyzed. It should be understood, however, that the rate of liberation from their insoluble forms, a matter of at least equal importance, is governed by many factors, and is therefore not necessarily proportional to the total amounts present.

For convenience in making application of the chemical analyses, the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In this the assumption is made that for ordinary types a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2 million pounds. It is understood, of course, that this value is only an approximation, but it is believed that with this understanding it will suffice for the purpose intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires to consider the information in that form.

With respect to the presence of limestone and acidity in different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages for the respective types, because of the extreme variations frequently found within a given soil type. In examining each soil type in the field, however, numerous qualitative tests are made which furnish general information regarding the soil reaction, and in the discussions of the individual soil types which follow, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping and soil treatment. It is often desirable, therefore, to determine the lime requirement for a given field, and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (page 37).

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amounts of organic carbon, nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in two million pounds of the surface soil of each type in Will county.

In connection with this table attention is called to the variation among the soil types with respect to their content of the different plant-food elements. It will be seen from the analyses that variations in the organic-carbon content of the different soils are accompanied by similar variations in the nitrogen content. The organic-carbon content, which serves as a measure of the total organic matter present, is usually from 10 to 12 times that of the total nitrogen. This relationship is explained by the well-established facts that all soil organic matter contains nitrogen and that most of the soil nitrogen (usually 98 per cent or more) is present in a state of organic combination. This close relationship is also maintained in the middle and lower sampling strata.

The range in content of organic matter and nitrogen in the different soil types, is wide, altho the major portion of the soils of Will county are well supplied with these materials. About 75 percent of the total area of the county consists of soils containing 40,000 pounds or more of organic carbon in the

surface 2 million pounds. The remaining area is made up mainly of the upland timber types and sandy soils. The most extensive soil type in the county, Brown Silt Loam, contains in the surface soil an average of 68,340 pounds per acre of organic carbon and 6,910 pounds of nitrogen. In a general way these amounts may be considered adequate for good crop production, but they are subject to gradual depletion, particularly when cultivated crops are largely grown. The part which remains year after year is that which has resisted decay and is of much less value in the soil than more "active" materials. For this reason the addition of fresh organic materials, such as stable manure, stalks, and green-manure crops are necessary to keep the soil permanently in the most productive state.

Other constituents are not so closely associated with each other as organic matter and nitrogen. However, there is some degree of correlation between sulfur, another element used by growing plants, and organic carbon. This is because a considerable, tho varying proportion of the sulfur in the soil exists in the organic form; that is, as a constituent of the organic matter. With the exception of Dune Sand, Brown Sandy Loam, and Yellow-Gray Silt Loam, all the types in the county contain fairly large amounts of sulfur. Dune Sand contains only 180 pounds of this element in 2 million pounds of soil; the peat soils, on the other hand, contain amounts ranging from 2,240 to 7,130 pounds. In most cases the sulfur content amounts to about two-thirds that of phosphorus. The sulfur available to crops is affected not only by the soil supply, but also by that brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently it is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption the amount of sulfur thus added to the soil is relatively large. At Urbana, during the eight-year period from 1917 to 1924, there was added to soil by the rainfall, 3.5 pounds of sulfur an acre a month as an average. Similar observations have been made in other localities for shorter periods. At Carlinville, in Macoupin county, the rainfall for seven months, April to October, 1922, brought down 34.85 pounds of sulfur an acre, or an average of 5 pounds a month. At Toledo, Cumberland county, from April to November, 1922, the average precipitation was 3 pounds an acre a month. The rainfall at Joliet, in Will county, from April thru September, 1922, carried down 20.62 pounds of sulfur an acre, or an average of 3.44 pounds a month for those months. The extreme range of variation in precipitation of sulfur over the state has varied in the observations taken, from .74 pound to a maximum of 10.22 pounds a month. These figures will afford some idea of the amount of sulfur added by rain and also of the wide variation in these amounts under different conditions. With the sulfur added from the atmosphere supplementing that contained in the soil, it would appear that there is probably no need for sulfur fertilizers in Will county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started at five experimental fields: namely, Raleigh, Toledo, Carthage, Hartsburg, and Dixon.

Phosphorus is fairly abundant in the upland prairie soils, which constitute approximately two-thirds of the area of the county. The minimum for the surface soil of any type in this group is 1,360 pounds an acre, while the average content is 1,770 pounds. Judging from the chemical composition alone, one would not expect a great need for phosphorus fertilization in these soils. However, there has been obtained a good response for the application of rock phosphate at the Joliet experiment field, as well as on many farms in the county. The Upland Timber soils, as a group, contain the least phosphorus of the Will county types, the lowest figure being only 380 pounds an acre for Dune Sand.

Potassium, as is usually the case, is deficient in Deep Peat, there being only 6,300 pounds in the surface stratum. The Medium Peats contain somewhat more, while the Peaty Loam contains approximately the same amount as Dune Sand, namely, 21,000 to 22,000 pounds. The more or less sandy soils, aside from containing less potassium than the heavier types, carry a large proportion of this element in the sand grains. The relatively small surface exposed in the case of these coarse particles greatly lowers the solubility and availability of the potassium in sand soils, but this is partly offset by the greater depth of the feeding zone for crop roots in sandy soils as compared with the heavier types. The other soil types of the county are well supplied with total potassium, the amounts in the upper sampling stratum ranging from approximately 32,000 pounds to over 48,000 pounds.

Both calcium and magnesium are well supplied in the soils of Will county. Calcium ranges, in the upper 6⅔ inches of soil, from 4,900 to 142,740 pounds an acre. Only one soil type, Dune Sand, contains less than 8,000 pounds of this element. The magnesium content ranges from the very low amount of 1,360 pounds an acre in Black Sandy Loam to 86,100 pounds in Gravelly Loam. These extreme types, however, occupy only small areas. The major portion of the soils of the county contain from one-half to two-thirds as much magnesium as calcium in the surface stratum.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper stratum, or with each other, it is necessary to bear in mind that the data as given for the middle and lower sampling strata are on the basis of 4 million and 6 million pounds of soil, and should therefore be divided by 2 and 3 respectively before comparing them with each other or with the data for the upper stratum, which are on a basis of 2 million pounds.

Considering the data in this way it will be noted in comparing the three strata with each other that some of the elements remain practically constant in amount thruout the entire depth sampled; others exhibit more or less variation at the different levels. Furthermore, these variations as a rule move in certain general directions, and by a careful study of them it is frequently possible to obtain clues as to the age or stage of maturity of the various soils, their agricultural importance and needs, and the nature of some of the processes going on in soil formation.

From this point of view it will be seen, in comparing the three strata with each other, that, with the exception of Deep Peat, all of the soil types diminish rapidly in organic matter and nitrogen with increasing depth, and that this diminution is very marked even in the middle stratum. The sulfur content diminishes markedly with increasing depth except in the case of the Peats. This is to be expected since a portion of the sulfur exists in combination with the soil organic matter, and inorganic forms of sulfur are not tenaciously retained by the soil against the leaching action of ground water. Phosphorus, on the other hand, is not removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in these forms in plant residues at the expense of the underlying strata. Consequently, almost without exception in Will county the surface soil contains a larger proportion of phosphorus than the middle stratum. The lower stratum usually contains approximately the same proportion of phosphorus as the middle stratum, or slightly more, because it has not been so heavily drawn upon.

The content of potassium in the different depths varies only slightly. Analyses of upland types show, however, that the other two important basic elements, calcium and magnesium, have undergone some shifting in the different levels. The calcium content, on the whole, is much higher than that of magnesium, indicating a more abundant supply of calcium in the soil-forming materials. However, with two exceptions the ratio of the calcium content to the magnesium content diminishes in the middle stratum as compared to the upper. This is accompanied by an increase in the amount of magnesium in the middle stratum and usually in the lower as well. As these two elements leach downward thru the soil, magnesium is more readily absorbed by the soil mass than calcium, and calcium is thus forced out into the solution to be carried farther down. Consequently, calcium does not begin to accumulate until it reaches the lowest level, and in counties farther south, where there is greater rainfall it is frequently carried down several feet. The terrace soils are beginning to show the results of this process, but in the bottom-land soils the effects are masked by those of overflow. This relationship does not exist in those soils in which leaching has not progressed far enough to remove the calcium carbonate.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is not possible to obtain this information exactly, especially for the deeper-rooted crops, it seems probable that practically all of the feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together, for a given soil type, the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

Considered in this manner the tables show that there is not only a wide diversity among the different soils with respect to a given plant-foot element, but that there is also a great variation with respect to the relative abundance of the various elements within a given soil type as measured by crop requirements. For example, in the most common soil type in the county, mapped as

Brown Silt Loam, Upland, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 18,850 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus, 4,870 pounds, contained in the same soil is equivalent to that contained in 28,650 bushels of corn, while in the same quantity of this soil there is present 226,250 pounds of potassium, the equivalent of that contained in approximately 1,200,000 bushels of corn. Yellow-Gray Silt Loam, the most common timber type in the county, presents a marked contrast in nitrogen content. It contains only 8,830 pounds an acre in the 40-inch stratum, or less than half the amount present in Brown Silt Loam, while the phosphorus and potassium contents are approximately the same in the two types. Deep Peat, on the other hand, as compared with Brown Silt Loam, contains more than six times as much nitrogen, or 119,420 pounds an acre; and nearly twice as much phosphorus, 7,840 pounds; but is strikingly low in potassium, containing only 20,780 pounds, or less than one-tenth as much as is contained in the same area of Brown Silt Loam.

Similar observations with respect to calcium are of more interest when applied to legumes rather than corn. The three kinds of soil discussed above, namely Brown Silt Loam, Yellow-Gray Silt Loam, and Deep Peat contain, respectively, in the 40-inch stratum 155,150 pounds, 87,030 pounds, and 431,190 pounds of calcium an acre. Since a ton of red clover hay contains 29 pounds of calcium, the above amounts are equivalent, respectively, to about 5,000 tons, 3,000 tons, and 15,000 tons of clover hay. All three of these soils contain calcium carbonate, the active material in limestone, within the 40-inch stratum, and this accounts for the high calcium content.

Very few soil types in Will county have been leached free of calcium carbonate thruout the entire 40 inches. Two such types are Dune Sand and Brown Sandy Loam, Upland. These contain, respectively, only 29,680 pounds and 41,680 pounds an acre of calcium (in forms other than carbonate) in the 40 inches, which amounts are equivalent to 1,000 and 1,500 tons of clover hay.

In examining the chemical data from the point of view last developed, that is, from the standpoint of the *total* amounts of plant-food elements in different soil types, one is impressed by the apparent relative abundance of the various elements as compared with the amounts removed in crops. It is obvious that the need for additions of a given element to increase crop yields is not necessarily due to too small a total amount of it in the soil, but that it may be, and usually is, due to *too slow a rate of becoming available.* This is a fortunate situation, since the durability of soils for cropping is due largely to the low solubility of the mineral elements of plant food, and in part to the resistance of the organic matter to complete destruction by decay. If the various essential elements were readily dissolved in the soil and the organic matter subject to complete decomposition, the soil would rapidly become depleted as a result of the leaching action of water, in spite of the great absorbing power of the soil mass. The problem of supplying the needs of crops then becomes one of maintaining a steady transformation of the various elements into available

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF WILL COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES
Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (1000, 1200)							
1026, 1226	Brown Silt Loam	68 340	6 910	1 130	950	35 940	9 870	11 750
1020	Black Clay Loam	84 660	9 510	1 290	1 290	38 520	15 130	20 520
1228.1	Brown Silt Loam On Tight Clay	66 340	6 860	1 320	880	40 280	12 280	9 000
1026.5	Brown Silt Loam On Rock	55 940	7 780	1 160	840	33 860	11 860	13 960
1060	Brown Sandy Loam	14 660	2 120	780	200	29 340	3 300	7 660
	Upland Timber Soils (1000, 1200)							
1034	Yellow-Gray Silt Loam	26 610	2 230	790	570	40 650	6 950	6 700
1035	Yellow Silt Loam	29 700	3 600	960	520	48 120	8 940	8 020
1081	Dune Sand	6 120	600	380	180	25 780	2 300	4 900
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	45 880	6 130	1 320	890	33 260	6 550	9 350
1560	Brown Sandy Loam	33 110	3 610	710	460	24 130	2 670	22 450
1526.4	Brown Silt Loam On Gravel	47 280	4 940	1 190	720	38 270	6 660	9 760
1560.4	Brown Sandy Loam On Gravel	43 480	4 620	1 480	780	29 500	5 560	11 940
1526.5	Brown Silt Loam On Rock	80 540	7 760	1 640	1 100	40 440	9 880	12 440
1581	Dune Sand	10 180	840	680	180	21 480	2 780	6 280
1534.4	Yellow-Gray Silt Loam On Gravel	27 820	3 300	960	500	31 820	5 780	9 740
1536	Yellow-Gray Silt Loam Over Gravel	39 200	4 340	1 200	580	33 000	6 540	11 000
1567	Yellow-Gray Sandy Loam Over Gravel	20 400	2 320	740	480	30 000	3 140	9 340
1561	Black Sandy Loam	57 720	5 980	1 120	780	19 780	1 360	9 540
1566	Brown Sandy Loam Over Gravel[1]							
1519	Brown Clay Loam	58 940	5 820	1 700	1 020	42 740	17 560	17 200
1534.5	Yellow-Gray Silt Loam On Rock	25 280	2 840	740	480	33 220	7 740	9 560
1520	Black Clay Loam	121 900	13 340	2 880	1 720	36 220	17 200	28 960
1590	Gravelly Loam	51 580	6 920	1 500	1 100	22 780	86 100	142 740
1597.5	Stony Brown Silt Loam On Rock	68 020	7 640	1 560	1 060	30 000	5 280	12 740
	Late Swamp and Bottom-Land Soils (1400)							
1454	Mixed Loam[2]							
1426	Brown Silt Loam	92 780	10 780	1 620	1 400	38 000	12 600	16 980
1454.5	Mixed Loam On Rock[2]							
1463	Black Mixed Sandy Loam On Rock[2]							
1450.1	Black Mixed Loam On Clay[2]							
1450	Black Mixed Loam[2]							
1401	Deep Peat[3]	282 980	17 140	1 320	7 130	6 300	4 990	130 280
1402	Medium Peat On Clay[3]	405 000	20 810	570	3 170	10 250	1 890	11 260
1410	Peaty Loam	147 440	15 520	860	2 240	22 800	4 800	16 280
1402.5	Medium Peat On Rock[3]	300 310	16 530	1 990	1 150	9 190	9 330	32 490
	Residual Soils (000)							
099	Rock Outcrop[1]							

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]Not analyzed.

[2]On account of the heterogeneous character of the Mixed Loams, chemical analyses are not included for these types.

[3]Amounts reported are for 1 million pounds of Deep Peat and Medium Peat.

forms during the growing season, from the reserves in the soil, or from added fertilizing materials, or from both. The above statements, therefore, are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF WILL COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (1000, 1200)							
1026, 1226	Brown Silt Loam	69 780	7 550	1 530	1 090	74 370	23 540	21 200
1020	Black Clay Loam	76 530	8 920	2 270	1 430	66 200	30 600	31 150
1228.1	Brown Silt Loam On Tight Clay	58 600	7 160	1 520	920	79 680	32 200	17 160
1026.5	Brown Silt Loam On Rock	76 720	8 640	2 160	1 240	68 360	18 720	20 240
1060	Brown Sandy Loam	23 660	3 360	1 360	360	57 480	7 720	13 440
	Upland Timber Soils (1000, 1200)							
1034	Yellow-Gray Silt Loam	21 100	2 940	1 200	600	81 020	26 260	12 560
1035	Yellow Silt Loam	17 040	3 200	1 800	560	95 960	28 680	15 320
1081	Dune Sand	5 760	1 040	920	520	51 960	5 160	10 320
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	63 080	6 720	2 020	1 120	68 260	15 400	17 320
1560	Brown Sandy Loam	36 330	3 930	1 070	710	44 080	6 310	18 390
1526.4	Brown Silt Loam On Gravel	56 520	6 440	2 120	1 260	77 260	20 300	20 900
1560.4	Brown Sandy Loam On Rock	65 880	7 640	3 080	1 400	58 920	11 320	18 360
1526.5	Brown Silt Loam On Rock	65 320	8 600	2 680	1 640	84 480	43 680	59 600
1581	Dune Sand	9 560	1 000	1 440	280	41 160	6 240	14 880
1534.4	Yellow-Gray Silt Loam On Gravel	25 480	3 560	1 800	480	63 200	21 000	19 720
1536	Yellow-Gray Silt Loam Over Gravel	42 600	5 360	2 000	760	66 120	14 960	22 880
1567	Yellow-Gray Sandy Loam Over Gravel	18 240	2 800	1 640	560	64 200	13 000	17 320
1561	Black Sandy Loam	29 720	2 760	1 320	640	34 600	3 640	16 040
1566	Brown Sandy Loam Over Gravel[1]							
1519	Brown Clay Loam	76 160	8 160	2 560	1 360	85 520	39 800	35 080
1534.5	Yellow-Gray Silt Loam On Rock	24 160	3 160	1 440	920	60 640	18 800	15 360
1520	Black Clay Loam	164 480	17 520	5 240	2 480	79 680	39 520	56 680
1590	Gravelly Loam[1]							
1597.5	Stony Brown Silt Loam On Rock	49 520	5 560	1 880	960	62 640	17 360	19 600
	Late Swamp and Bottom-Land Soils (1400)							
1454	Mixed Loam[2]							
1426	Brown Silt Loam	118 280	13 840	3 000	1 920	75 000	25 040	30 440
1454.5	Mixed Loam On Rock[2]							
1463	Black Mixed Sandy Loam On Rock[2]							
1450.1	Black Mixed Loam On Clay[2]							
1450	Black Mixed Loam[2]							
1401	Deep Peat[3]	768 720	41 620	2 800	21 220	5 840	9 060	165 160
1402	Medium Peat On Clay[3]	478 920	27 680	1 260	4 580	38 900	12 760	16 740
1410	Peaty Loam	115 240	13 320	1 400	1 600	53 880	12 840	25 920
1402.5	Medium Peat On Rock[1]							
	Residual Soils (000)							
099	Rock Outcrop[1]							

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Not analyzed.

[2]On account of the heterogeneous character of the Mixed Loams, chemical analyses are not included for these types.

[3]Amounts reported are for 2 million pounds of Deep Peat and Medium Peat.

do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration, aside from merely the amount of plant-food elements present in the soil. Much depends

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF WILL COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES
Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (1000, 1200)							
1026 } 1226 }	Brown Silt Loam	40 570	4 390	2 210	990	120 620	80 050	122 200
1020	Black Clay Loam	38 180	5 350	3 180	1 260	118 220	67 820	70 140
1228.1	Brown Silt Loam On Tight Clay	33 600	5 580	2 100	780	118 740	67 980	44 220
1026.5	Brown Silt Loam On Rock[1]							
1060	Brown Sandy Loam	15 480	1 920	1 800	180	84 000	10 320	20 520
	Upland Timber Soils (1000, 1200)							
1034	Yellow-Gray Silt Loam	28 110	3 660	2 160	780	118 470	78 810	67 770
1035	Yellow Silt Loam	27 000	4 680	2 530	840	140 760	140 040	206 220
1081	Dune Sand	7 500	840	1 380	600	76 020	8 040	14 460
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	36 420	4 410	3 000	930	104 010	23 310	27 000
1560	Brown Sandy Loam	16 800	1 740	1 260	540	68 400	11 520	27 760
1526.4	Brown Silt Loam On Gravel	51 540	6 600	3 000	1 440	109 200	49 200	38 520
1560.4	Brown Sandy Loam On Gravel[1]							
1526.5	Brown Silt Loam On Rock[1]							
1581	Dune Sand	13 380	1 920	2 100	240	60 780	10 200	23 100
1534.4	Yellow-Gray Silt Loam On Gravel	38 580	4 020	3 360	840	92 940	52 020	49 740
1536	Yellow-Gray Silt Loam Over Gravel	27 840	5 220	3 480	480	99 360	34 380	29 940
1567	Yellow-Gray Sandy Loam Over Gravel	26 280	3 900	2 820	1 020	95 580	30 480	32 460
1561	Black Sandy Loam	24 000	1 920	2 040	480	55 140	2 520	23 460
1566	Brown Sandy Loam Over Gravel[1]							
1519	Brown Clay Loam	64 680	7 380	3 660	1 200	126 120	53 520	50 160
1534.5	Yellow-Gray Silt Loam On Rock[1]							
1520	Black Clay Loam	143 040	16 380	5 460	1 250	110 940	53 100	65 880
1590	Gravelly Loam[1]							
1597.5	Stony Brown Silt Loam On Rock[1]							
	Late Swamp and Bottom-Land Soils (1400)							
1454	Mixed Loam[2]							
1426	Brown Silt Loam	61 380	7 800	3 360	1 140	122 640	40 680	36 900
1454.5	Mixed Loam On Rock[2]							
1463	Black Mixed Sandy Loam On Rock[2]							
1450.1	Black Mixed Loam On Clay[2]							
1450	Black Mixed Loam[2]							
1401	Deep Peat[3]	1335750	60 660	3 720	41 670	8 640	12 000	135 750
1402	Medium Peat On Clay[3]	522 180	33 300	1 670	6 800	96 260	39 240	38 030
1410	Peaty Loam	15 780	2 400	720	900	79 140	42 300	86 880
1402.5	Medium Peat On Rock[1]							
	Residual Soils (000)							
099	Rock Outcrop[1]							

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Not analyzed.

[2]On account of the heterogeneous character of the Mixed Loams, chemical analyses are not included for these types.

[3]Amounts reported are for 3 million pounds of Deep Peat and 4½ million pounds of Medium Peat on Clay.

upon the nature of the crops to be grown, as to their utilization of plant-food materials, and much depends upon the condition of the plant-food substances themselves as to their availability. Finally, in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. The data do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon, and in this way, contribute fundamental information for the intelligent planning, in a broad way, of systems of soil management for conserving and improving the fertility of the land.

DESCRIPTION OF SOIL TYPES

UPLAND PRAIRIE SOILS

The upland prairie soils of Will county cover 571.38 square miles, or 68.44 percent of the total area of the county. These soils are usually dark in color, owing to the accumulation of organic matter which has been derived very largely from the fibrous roots of the prairie grasses that once covered this land. The network of grass roots was protected from rapid and complete decay by the covering of fine, moist, surface soil and by the mat of vegetative material formed by the debris of the dead leaves and stems.

The upland prairie soils in this county include some areas of recent timber growth, where certain varieties of trees have invaded the prairies but have not grown for a long enough period to produce the characteristic timber soil.

Brown Silt Loam (1026, 1226)

Brown Silt Loam, Upland, is the most extensive soil type in Will county, occupying 544.46 square miles, or about 65 percent of the area of the county. The profile of this type as mapped varies considerably in different portions of the county as regards color, texture, thickness, and physical properties of the horizons, and also as regards depth to glacial drift. Most of the type is undulating to rolling, with good natural drainage. Erosion is active on the steeper slopes. Calcareous drift occurs at an average depth of about 25 inches over practically the entire area occupied by this type. In the region near the sandy terrace, an appreciable amount of sand occurs in the surface and subsurface horizons.

The A_1 horizon varies in depth from 6 to 13 inches, in color from light brown to nearly black, and in texture as above noted. The A_2 horizon, which extends to about 15 inches in depth, varies from a yellowish brown to a light brown silt loam, the yellowish tint occurring in the areas which have sufficient slope for good surface drainage. The B horizon, with an average thickness of 10 inches, varies from a slightly compact, lightly mottled, yellow silt loam to a compact, mottled, drabbish yellow silty clay loam, with glacial gravel present in some places. The C horizon is a friable, usually calcareous, yellow silt loam, containing glacial gravel and spotted with yellow iron concretions.

Management.—The variations in Brown Silt Loam in Will county must be recognized in its management if the best results are to be secured. Tests indicate that the higher, lighter-colored areas, unless erosion has exposed the calcareous subsoil, need about 2 to 3 tons of limestone an acre for alfalfa or sweet clover. Many of the low-lying, dark-colored areas need no limestone. Much of this type is becoming too low in organic matter to allow good seed-bed preparation with a minimum amount of work. The regular growth of clover, preferably sweet clover, and the plowing down of part of the crop as a green manure, will be found to be a profitable practice. Sweet clover may be seeded in the small grain and pastured during the fall and then plowed down for corn the next spring. This practice will result in a marked increase in the corn yield, particularly on the lighter-colored portions of the type.

Results secured on the Joliet experiment field (see page 48) justify recommending the application of rock phosphate, particularly if only a small amount of manure is available. Smaller returns from the use of this material are to be expected on the dark-colored portions of the type. The application of potash, in the form of kainit, in addition to residues, lime, and rock phosphate, does not give sufficient increase in yield to pay the cost of material in the quantities employed. The favorable results with corn and wheat suggest that this material might be used in smaller amounts at a profit. However, these results are rather exceptional in this region, and for this reason such use of potash in general farming is advised at present only in an experimental way, and attention is called to the probability that it would not be found to pay on the darker-colored portions of the type.

To summarize: It is recommended that sufficient limestone be used to grow good alfalfa or sweet clover, that a portion of these legumes be plowed down at regular intervals, and that rock phosphate or, if preferred, acid phosphate or steamed bone meal be used. In addition, the trial of one of the potash salts for corn is suggested, particularly on the lighter-colored portions of the type.

Black Clay Loam (1020, 1220)

Black Clay Loam, Upland, occurs in small areas thruout the county with the exception of those portions occupied by the terrace and timber soil types. Numerous narrow strips of Black Clay Loam occur along the small streams. In the northern part of the county where the knob-and-basin type of topography prevails, the depressions, some of which are under water a part of the year, are usually occupied by Black Clay Loam. This type occupies 23.75 square miles, or nearly 3 percent of the total area of the county. The topography is flat and the drainage is usually fair to good.

The A_1 horizon varies from a granular, black, silty clay loam to a clay loam, and has an average depth of about 8 inches. The A_2 horizon extends to a depth of about 16 or 17 inches and is a plastic, black clay loam. The B horizon is a plastic, compact, mottled, drabbish yellow to drab clay loam. The thickness of the upper subsoil is about 28 or 30 inches. Below this, the texture of the subsoil is variable on account of the varying depth to the drift, which

is a calcareous, sandy to silty clay or clay loam, drab or gray in color, and strongly stained with brownish red iron concretions.

Management.—Black Clay Loam is a potentially productive soil and no treatment other than the regular plowing down of a leguminous green manure is advised. An account of field experiments on this type as represented by the Hartsburg field will be found on page 56.

Brown Silt Loam On Tight Clay (1028.1, 1228.1)

Brown Silt Loam On Tight Clay occupies only about four-fifths of a square mile in the county. It is found only in two localities; namely, Sections 15 and 16, Township 34 North, Range 13 East, and Section 2, Township 32 North, Range 10 East. The flat topography of the type, together with its impervious clay subsoil, causes drainage to be poor. These areas were formerly small lake basins.

The A_1 horizon, which is about 8 inches in thickness, is a light to medium brown silt loam. The A_2 horizon, extending to a depth of about 14 or 15 inches, varies from a light brown to yellowish brown silt loam to silty clay loam. The B horizon is a plastic, sticky, very compact, drabbish yellow to yellow clay, which grades into a gray clay stained with red to brown iron concretions. The C horizon is found at a depth of about 36 inches and varies from a slightly compact, grayish yellow to yellow clay loam.

Management.—Drainage is the chief problem in the management of this type. If tile are laid, the laterals should be about 4 rods apart. Difficulty will be encountered in getting an outlet because of the topographic position of the type. The soil is medium acid and requires about 2 tons of limestone an acre to grow sweet clover.

Brown Silt Loam On Rock (1026.5)

Brown Silt Loam On Rock, as a soil, is of little agricultural value aside from its value as permanent pasture. The underlying rock is limestone. Most of the areas are found in the vicinity of Joliet along DesPlaines river where the limestone outcrops occur. Since the bed rock is near the surface, very little soil material occurs and the horizons have not been very definitely developed. The type covers a total area of 2.21 square miles.

The A_1 horizon extends to a depth of 7 to 15 inches and is a brown to dark brown silt loam, well supplied with organic matter. This changes into a rather heavy, silty clay loam directly above the limestone. This layer is only a few inches in thickness. The limestone is often found disintegrated into finely divided material to a depth of 2 or 3 inches.

Management.—This type should be left in permanent pasture unless used as a source of limestone for commercial and agricultural purposes.

Brown Sandy Loam (1060, 1260)

Brown Sandy Loam, Upland, is of minor importance. It occurs as scattering areas in the Brown Silt Loam region, north of the Kankakee river terrace.

These areas are formed from sand material blown by the wind from the terraces onto the upland. Very little horizon development is found, as these areas are of late origin. The type occupies a total of only 77 acres.

The surface soil, extending to about 4 inches in depth, is a brown sandy loam. Below this the soil is an incoherent mass of brownish yellow to yellow sand.

Management.—The organic-matter content of this type is low. Legumes should be grown to correct this deficiency after about 2 tons of limestone an acre have been applied to counteract the slight acidity which occurs. The results from the Oquawka experiment field, page 59, may be studied to advantage in connection with the management of this type.

UPLAND TIMBER SOILS

The upland timber soils of Will county include three types, which cover in total an area of 69.10 square miles, or 8.28 percent of the area of the county. They comprize the irregular zones or belts of light-colored soils along the streams and on the moraines in the eastern part of the county.

These soils are characterized by their yellowish gray color due to the low organic-matter content, which is the result of long-continued growth of timber. After the forests invaded the prairies, two conditions were produced: the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the organic-matter content; and the trees themselves added very little to the soil, for the leaves and other debris either decayed completely or were burned by forest fires. Moreover, the organic matter that probably had accumulated prior to the forest invasion was dissipated during the occupation of the land by the trees.

Yellow-Gray Silt Loam (1034, 1234)

Yellow-Gray Silt Loam, Upland, occurs chiefly in the vicinity of DesPlaines river and its tributaries and in the eastern part of the county. The type occupies 61.92 square miles, or 7.42 percent of the total area of the county. In topography it varies from undulating to rolling, having a knob-and-basin character where it occurs adjacent to Cook county. Surface drainage is well established and care must be exercised to reduce erosion to a minimum on the slopes. Very little standing timber is found on this type.

The A_1 horizon, which is about 7 inches deep, varies from a brownish yellow to a grayish yellow silt loam. The A_2 horizon, extending to about 14 inches in depth, is a mottled, grayish yellow silt loam. The B horizon is a slightly plastic, compact, mottled yellow, silty clay loam, slightly stained with red iron concretions. The C horizon, starting at a depth of about 24 inches, is a friable, pale yellow or reddish yellow, gravelly, silty clay loam which effervesces in contact with acid at a depth of about 26 inches.

Management.—Yellow-Gray Silt Loam is deficient in organic matter and nitrogen. Many of the slopes occupied by this type will grow alfalfa and sweet clover without limestone but the more level areas require an application of 2

to 3 tons an acre. Particular attention should be given to the regular plowing down of a leguminous green manure and many of the slopes must be farmed with care to prevent serious erosion.

Results secured on the Antioch field, which is located on soil similar to this type, indicate that some form of phosphate can be used with profit. Bone meal has demonstrated for many years a highly beneficial effect. Recent experiments indicate that rock phosphate will produce a similar effect. For further discussion of these experiments, see page 57.

Yellow-Silt Loam (1035, 1235)

Yellow Silt Loam is an unimportant type in Will county because of its small acreage. There are only 6.96 square miles in the entire county. The character of the type varies greatly, owing to differences in the rate of erosion caused chiefly by differences in the slopes.

The surface soil is usually a yellow or grayish yellow silt loam. It may be a yellow clay or even gravelly glacial drift, depending on the amount of erosion. Where the areas have been left in permanent pasture, there is an accumulation of a thin, dark-colored surface soil. The subsoil varies as does the surface but generally consists of a compact gravelly drift which effervesces with acid.

Management.—It is advised that the Yellow Silt Loam be left in permanent pasture for the most part. The less steep slopes may be successfully farmed if care is used to reduce erosion. If this type is farmed, however, particular attention must be given to plowing down green manures and crop residues at frequent intervals.

Dune Sand (1081)

Dune Sand, Upland, is a minor type in importance. It occupies, all told, only 141 acres in Will county. Nearly all the areas occur in Wesley township (Township 32 North, Range 10 East) and have been formed by the sand having been blown out of the Kankakee terrace and deposited upon the upland.

The surface, to a depth of 2 or 3 inches, is a brownish yellow sand or sandy loam. Below this shallow surface, an incoherent yellow sand occurs without change to the depth of the sand deposit, except for occasional thin layers or bands of silty to clayey material of wind-blown origin.

Management.—This unimportant type is poor agricultural soil. It has a low water-holding capacity, hence is drouthy, and is low in nitrogen and organic matter as well as in the other elements of plant food. It is suggested that anyone interested in the management of this type study the results from the Oquawka experiment field (see page 59) and also write to the Agricultural Experiment Station for further information.

TERRACE SOILS

There are two main terraces in Will county, the DesPlaines river terrace and the Kankakee river terrace. These bench-like formations were built up by

deposits from the sediment-laden streams during the time when immense volumes of water were coming from the melting glaciers. The swift current carried large boulders and much coarse sediment, which were later more or less buried by finer material.

Brown Silt Loam Over Gravel (1527)

Brown Silt Loam Over Gravel occurs along DuPage river and north of Wilmington, adjacent to Kankakee and DesPlaines rivers. The areas along DuPage river have numerous boulders scattered over the surface, many of which have been gathered up and placed in the fence rows. The topography of the type varies from flat to undulating. Drainage is generally well taken care of on account of the gravelly substratum that occurs. In the areas north of Wilmington the drainage is not so good because the gravel layer lies much deeper. The total area of this type is 29.19 square miles, or 3.5 percent of the area of the county.

The A_1 horizon, which is about 8 inches in depth, varies in color from a light brown to dark brown or black, and in texture from a sandy silt loam to a heavy silt loam. The A_2 horizon, extending to a depth of 15 or 16 inches, varies from a yellowish brown to a light brown silt loam. The B horizon, usually yellow in color, varies from a friable to a slightly compact, silty clay or clay loam, with a mixture of some sand. At a depth of 28 or 30 inches yellow sandy loam occurs. Sandy, gravelly material usually occurs at a depth varying from 33 to 45 inches. Often this gravelly substratum is calcareous.

Management.—Brown Silt Loam Over Gravel is a productive soil, well adapted to the growth of any of the crops common to the region. It varies in acidity but ordinarily does not need more than 2 tons of limestone an acre to grow sweet clover. It is excellent alfalfa land. The reader is refererd to the discussion of Brown Silt Loam, Upland, page 15, for suggestions regarding the management of this terrace type.

Brown Sandy Loam (1560)

Brown Sandy Loam, Terrace, occurs principally in the southwestern corner of the county, in the large terrace area formed by the Glacial Kankakee river. The type covers 46.26 square miles, or 5.54 percent of the area of the county. Its topography varies from flat to undulating, the undulations being caused by the wind having blown the sand into ridges. Drainage is poor to fair, owing to the tendency of the open ditches and tile to fill with sand and also to the high water table which exists.

The A_1 horizon, with an average depth of 7 inches, varies from a light brown to a medium brown sandy loam. The A_2 horizon which extends to about 15 inches in depth, is a yellowish brown sandy loam or a yellow sand. In some of the low-lying areas this horizon occurs as a coarse-grained gray sand. The B horizon varies from a yellow silty sandy loam to a yellow sand. Along Horse creek the sand is deposited upon a gravelly material which occurs at a depth of 28 to 40 inches below the surface.

Management.—Brown Sandy Loam, Terrace, as it occurs in Will county, is not a desirable general farming soil. Its drouthy nature, the difficulty of securing proper drainage, and its low content of the elements of plant food are the chief reasons for its relatively low agricultural value. An application of 2 to 3 tons of limestone an acre is needed to grow sweet clover. The only specific recommendations which can be made at the present time for the management of this type are that limestone be applied, sweet clover be seeded for pasture and for green manure, and early maturing crops be grown.

Brown Silt Loam On Gravel (1526.4)

Brown Silt Loam On Gravel occurs mainly on the terrace formation in the vicinity of the towns of Plainfield and Channahon. The topography of the type is flat to undulating. The stratified, calcareous, sandy, and gravelly terrace material underlying the soil varies from a few feet to 50 or more in thickness. To the south of Plainfield an area occurs that has only a thin stratum of gravel deposited upon a limestone bed. The type occupies 18.29 square miles; or 2.19 percent of the area of the county.

The A_1 horizon is about 6 inches in depth and varies from a light brown to a medium brown silt loam. The A_2 horizon, averaging from 10 to 20 inches in thickness, is a light brown to a yellowish brown silt loam, becoming somewhat sandy toward the bottom of the horizon.

Management.—Brown Silt Loam On Gravel is drouthy because of the nearness of the underlying gravel to the surface. It is slightly acid and requires a light application of limestone for sweet clover or alfalfa. Early maturing crops should be grown on this land to escape the drouth. Alfalfa does well because of its deep-rooting habit.

Brown Sandy Loam On Gravel (1560.4)

Brown Sandy Loam On Gravel occurs as scattering areas in the three main river basins, the largest of which is south of Kankakee river at Lorenzo. The type occupies a total area of 1,056 acres. Its topography is undulating. Drainage is excessive on account of the gravelly substratum. The depth to the gravel bed varies from 16 to 29 inches below the surface. In certain restricted areas the gravelly substratum contains numerous stones varying from 4 or 5 inches to 10 or 12 inches in diameter.

The A_1 horizon about 5 inches in depth, is a sandy loam varying in color from light brown to medium brown. The A_2 horizon, which varies in thickness, is a coarse-grained, yellowish brown sandy loam resting on the gravel bed at an average depth of about 20 inches.

Management.—This type is drouthy because of the nearness of the gravel to the surface. Early maturing crops should be grown to avoid so far as possible the effects of this condition. The type is low in organic matter, and it is recommended that legumes be grown to correct this deficiency. A light application of limestone is probably needed for sweet clover or alfalfa, tho the gravel substratum is high in carbonates.

Brown Silt Loam On Rock (1526.5)

Brown Silt Loam On Rock (Limestone) occurs principally on the borders of the DesPlaines river valley. The three main areas are found, in the vicinity of Joliet, between Kankakee and DesPlaines rivers at Drummond, and along DuPage river south of Plainfield. The topography of the type where the limestone occurs near the surface is flat to undulating; where the limestone is deeper, it becomes gently rolling. Drainage is usually poor on account of the irregularity of the contour of the limestone surface and the impossibility of constructing ditches. The type occupies 17.11 square miles, or 2.05 percent of the areas of the county.

The A_1 horizon is a medium to dark brown silt loam of a sandy phase and is about 4 or 5 inches in depth. The A_2 horizon is a silt loam varying from 6 to 20 inches in depth and from light brown to yellow in color. It is compact and sandy in texture just above the limestone which has weathered to a depth of 2 or 3 inches.

Management.—Brown Silt Loam On Rock is, for the most part, adapted only to permanent pasture. The depth to bed rock varies and where it approaches 30 inches, general farming may be carried on successfully, tho proper drainage is difficult to secure because of the basin-like formation of the bed rock. The soil is not acid, or only very slightly so.

Dune Sand (1581)

Dune Sand, Terrace, occurs in the southwestern corner of the county. The dunes vary from a foot or two to as much as 30 feet in height. Blowouts are common thruout the type. Dune Sand, Terrace, occupies a total of 7.16 square miles in Will county.

The surface two or three inches of soil is a yellow to brownish yellow sand. Below this shallow surface an incoherent yellow sand occurs to the full depth of the deposit.

Management.—Dune Sand, Terrace, as it occurs in Will county, is of higher agricultural value than is common for the type because of its finer texture. It contains more or less fine sand with an appreciable amount of silt. It is, however, very deficient in nitrogen and organic matter, and most of the areas of the type are acid. Good sweet clover and alfalfa can be grown on this soil following the application of about 3 tons of limestone an acre, and very satisfactory grain crops can be grown following the above legumes. This land should be cropped in a short rotation in order that frequent additions of nitrogenous organic matter may be made by plowing down clover, preferably sweet clover. The reader is referred to the results from the Oquawka experiment field, page 59, for further suggestions regarding the management of this type.

Yellow-Gray Silt Loam On Gravel (1534.4)

Yellow-Gray Silt Loam On Gravel occupies small, scattering areas thruout the terraces of the county, with the most extensive areas near Plainfield on

DuPage river. It covers a total of 2.36 square miles. The type is undulating in topography.

The A_1 horizon, averaging about 6 inches in depth, is a silt loam, floury in texture, and brownish yellow to grayish yellow in color. The A_2 horizon extends to about 11 inches and is a grayish yellow silt loam. The B horizon is a compact, mottled, yellow silt loam, changing to a layer of compact, sticky, yellowish red clay about 2 to 3 inches in thickness directly above the stratified bed of calcareous gravel. The depth to the gravel varies from 17 to 22 inches.

Management.—Yellow-Gray Silt Loam On Gravel is low in organic matter, usually slightly acid in the surface, and subject to drouth. It is a good soil for alfalfa and sweet clover following the application of about 2 tons of limestone an acre. The selection of early-maturing crops helps to avoid the bad effects of dry weather to which crops growing on this land are sensitive.

Yellow-Gray Silt Loam Over Gravel (1536)

Yellow-Gray Silt Loam Over Gravel comprizes 1.94 square miles of the area of the county. The type occurs in small areas, nearly all of them being located north of Kankakee river and along DuPage river. The topography of the type is undulating and the underdrainage is good.

The A_1 horizon is about 6 inches in depth and varies from a brownish yellow to grayish yellow silt loam. The A_2 horizon, extending to about 14 inches, is a grayish yellow silt loam with an appreciable amount of sand present. The B horizon is a compact, mottled, yellow silt loam, which extends to a depth of about 26 inches. The C horizon is a friable, yellow, sandy silt loam which rests on stratified sand and gravel at a depth of 32 to 45 inches.

Management.—Yellow-Gray Silt Loam Over Gravel is similar to the preceding type excepting that it is not drouthy. It is a fairly good general farming soil and will produce satisfactory crops following the application of sufficient limestone to grow the clovers and the plowing down of fresh organic matter, preferably sweet clover.

Yellow-Gray Sandy Loam Over Gravel (1567)

Most of the areas of Yellow-Gray Sandy Loam Over Gravel are located north of Kankakee river, south of Wilmington. Some of these areas are dune-like in formation, making it difficult to separate consistently this type from Dune Sand. The topography of the type is undulating to gently rolling. It covers an area of 2.32 square miles. Drainage is good on account of the porous condition of the sand and gravel stratum.

The A_1 horizon, which is about 6 inches in depth, is a yellowish gray sandy loam. The A_2 horizon, extending to about 14 inches, is a grayish yellow sandy loam. The B horizon is a coarse-grained yellow sand, becoming slightly compact at about 32 inches owing to the presence of some clayey material. The depth to the gravelly substratum varies from 45 to 50 inches.

Management.—This type requires approximately the same treatment as Yellow-Gray Silt Loam Over Gravel. It is, however, a poorer soil and will not respond so satisfactorily to good treatment and management.

Black Sandy Loam (1561)

Black Sandy Loam occurs in the sandy area south of Kankakee river. The type occupies a total area of 5.58 square miles. In topography it is flat and the drainage is only fair.

The A_1 horizon, which is about 10 inches in depth, is a black sandy loam. The A_2 horizon, to a depth of 28 inches, is a yellow sand. The B horizon is a yellow sandy clay or a grayish yellow sand.

Management.—Black Sandy Loam, even tho very dark in color, is deficient in easily decomposable organic matter. It contains many alkali spots and is very generally in need of improved drainage. The harmful effects of the alkali may be overcome by the application of potash salts at the rate of about 100 pounds an acre for corn.

Brown Sandy Loam Over Gravel (1566)

Brown Sandy Loam Over Gravel occupies a total area of 4.34 square miles. The type is located north of Kankakee river in the vicinity of Wilmington. The topography is undulating. Drainage is good, owing to the presence of the gravelly substratum.

The A_1 horizon is about 8 inches in depth and is a brown sandy loam. The A_2 horizon, extending to about 17 inches, varies from a grayish brown or light brown to a yellowish brown sandy loam. The B horizon, which extends to a depth of about 27 inches is a medium-grained, somewhat compact, yellow sand with some clay present. Below this depth there is a coarse-grained yellow sand with an admixture of fine-gravelly material occuring at 34 to 38 inches, underneath which calcareous, stratified sand and gravel are found.

Management.—Brown Sandy Loam Over Gravel is not markedly deficient in organic matter, tho regular additions are needed to keep a supply of readily decaying material present. The surface soil is somewhat acid. About 2 tons of limestone an acre is needed for sweet clover or alfalfa. This is a good soil for truck farming.

Brown Clay Loam (1519)

Brown Clay Loam occurs south of Drummond, occupying a total area of less than a mile and a quarter. The drainage of these areas is insufficient because the topography is flat and also because of the difficulty in getting proper outlets.

The A_1 horizon is a brown to black clay loam about 7 inches in depth. The A_2 horizon, extending to about 17 inches in depth, is a plastic, compact, drab clay loam. The B horizon is a very sticky, compact, drab clay, becoming at 30 inches slightly lighter in color, more compact, and spotted with yellow and red iron concretions.

Management.—Brown Clay Loam can best be utilized, at least for the present, as permanent pasture.

Yellow-Gray Silt Loam On Rock (1534.5)

Yellow-Gray Silt Loam On Rock is a type of minor importance, as it occupies a total area of only 13 acres. The depth to limestone varies from 8 to 15 or 16 inches. Since the limestone is so near the surface, the type is of no agricultural value aside from permanent pasture.

Black Clay Loam (1520)

Black Clay Loam, Terrace, occupies 1.67 square miles, or .2 percent of the area of the county. It is found principally in the DuPage river terrace, where it is associated with Brown Silt Loam. The topography is flat. Most of the areas have been formed under fair drainage conditions.

The A_1 horizon, which is about 7 inches in depth, varies from a black silty clay loam to clay loam. The A_2 horizon, which extends to about 18 inches, is a heavy, plastic, compact, black clay to clay loam. The B horizon is a black to drab clay loam, spotted with yellowish brown iron concretions.

Management.—This type does not need limestone. The B horizon is usually slightly calcareous. The important requirements in the management of this type are the improvement of the drainage on areas which are not now well drained, and some provision for returning fresh organic matter as a means of maintaining a condition of good tilth.

Gravelly Loam (1590)

Gravelly Loam occupies a total area of only 32 acres in Will county. It is found on the slopes from one terrace level to another. The type is non-agricultural. Some of the material is used for road construction. Bluegrass pasture and sweet clover do fairly well on this type except in seasons of extreme drouth.

Stony Brown Silt Loam On Rock (Boulders) (1597.5)

Stony Brown Silt Loam On Rock covers an area of 3.17 square miles. The type is non-agricultural aside from some little use as pasture. Numerous boulders, varying from 10 inches to 2 or 3 feet in diameter, are scattered over the surface and thruout the soil mass. These boulders, probably of Canadian origin, consist of granites, sandstones, serpentine basalts, and limestone. Niagara limestone bed rock underlies the entire area. Drainage is poor on account of the fairly flat topography and the impracticability of constructing outlets thru the boulders and limestone bed rock.

The A_1 horizon is about 4 or 5 inches in depth and is a dark brown silt loam. The organic-matter content is usually high. The A_2 horizon may vary from 3 to 15 inches in depth, depending on the number of boulders present. It rests on limestone bed rock. It is slightly darker in color and heavier in texture than the surface.

Management.—The numerous boulders present make it impossible to use this type for any purpose other than pasture.

LATE SWAMP AND BOTTOM-LAND SOILS

In the group designated as Late Swamp and Bottom-Land Soils are included the bottom lands or flood plains along streams, the swamps, and the poorly drained lowlands. Much of the soil is of alluvial formation and the land is subject to overflow. Some of the soils included in this group are capable of better drainage and if drained would become good farming land; others cannot, at least for the present, be economically drained.

Mixed Loam (1454)

Mixed Loam is found along the small streams in both the timber and prairie areas where the conditions have been such as to allow much mixing of the material deposited. This type cannot be adequately described because of its variations. It is mapped as Mixed Loam because it consists of a mixture of various soil types, which cannot be consistently separated; moreover, the next flood may cause a complete change in its character. The type covers 19.56 square miles, or 2.34 percent of the area of the county.

The A_1 horizon varies in general from a brown to yellowish brown or yellowish gray silt loam or sandy loam.

Management.—Much of this type is subject to overflow, and for this reason can be best utilized as permanent pasture. The frequent overflows maintain the soil in a sweet condition and leave much sediment which is rich in the elements of plant food.

Brown Silt Loam (1426)

Brown Silt Loam, Bottom Land, occurs as overflow land along small streams in the prairie and also along DuPage river. However, it is overflowed little during the growing season. It occupies 2.38 squares miles, or .28 percent of the area of the county.

The A_1 horizon, extending to about 12 inches in depth, is a brown silt loam. The A_2 horizon,which extends to a depth of about 22 inches, is a light brown to medium brown silt loam. Below this the material is a friable, yellowish brown to yellow silt loam, changing at about 30 inches to a slightly compact, grayish yellow silt loam or yellowish silty clay loam.

Management.—The areas which are subject to overflow during the growing season should be left in permanent pasture. This type is rarely acid and it is constantly enriched by fresh soil material deposited after heavy rains.

Mixed Loam On Rock (1454.5)

Mixed Loam On Rock has no agricultural value other than for grazing purposes. Nearly all of this type is located along DesPlaines river north of Joliet. It is a low, flat, poorly drained region, which is more or less covered with water

on account of the irregularity of the rock surface and the shallow channel thru which DesPlaines river flows, permitting the river to spread freely over the entire lowlands. The type covers an area of 9.14 square miles.

Since the limestone is so near the surface, very little soil development has taken place. The surface soil, varying in depth from 4 to 9 or 10 inches, is brown to black in color and varies from a silt loam to a silty clay loam or mixed sandy loam. The soil directly above the limestone is usually darker in color and heavier in texture than at the surface. The soil material is in a more or less water-logged condition the year round.

Management.—The only use which can be made of this land is to leave it in pasture and, wherever possible, to turn the stock in for grazing.

Black Mixed Sandy Loam On Rock (1463)

Black Mixed Sandy Loam On Rock is one of the minor types in the swampy regions of the county, occupying only 2.66 square miles. It occurs as poorly drained areas in depressions in the limestone beds and in old channels in the DesPlaines and DuPage river terraces. With limestone near the surface and numerous boulders scattered over the surface, it is impossible economically to improve the drainage.

The A_1 horizon varies from brownish black to black in color and from a peaty loam to a sandy loam in texture. It is about 6 inches in depth. The soil material below the surface is variable in depth depending on the boulders present and the nearness of the limestone to the surface. It is, however, usually a slightly plastic, fairly compact, drabbish gray to grayish yellow clay.

Management.—This type has no agricultural value other than for grazing.

Black Mixed Loam On Clay (1450.1)

Black Mixed Loam On Clay is found in Township 33 North, Range 15 East, in the region known as Eagle Lake. It is probably a lacustrine deposit. Formerly the area was poorly drained because there was no outlet, but within recent years a channel has been cut thru the upland which gives sufficient drainage to the old lake bed. The type, as mapped, is so variable that a definite profile description cannot be written.

The A_1 horizon is about 8 inches in depth and varies from a brownish black peaty loam to a brown or black sandy loam, with a mixture of clay, silt, and gravelly material consisting of shale and sandstone. The area was formerly covered by a deposit of peat or muck which has been burned off. The A_2 horizon is, in general, a compact clay, varying in color from light gray to gray or drabbish blue to drab. It extends at least to 40 or 45 inches in depth. Layers of shale and a poor grade of coal 2 to 3 inches in thickness are found at a depth of 3 to 5 feet below the surface.

Management.—No limestone is required on this type. Drainage has been fairly well established. Small grains produce fair yields and truck gardening is being practiced on part of the area with varied success.

Black Mixed Loam (1450)

Black Mixed Loam occupies the swampy, poorly drained areas in the upland as well as in the terraces. The individual areas of this type are all small. The type occupies a total area of 5.16 square miles.

The A_1 horizon, extending to a depth of about 7 inches, varies from dark brown to black in color and from a peaty loam, sandy in texture, to a silt or clay loam. The A_2 horizon, which extends to 17 or 18 inches in depth, is a slightly plastic, compact, silty clay or clay loam, brown to black in color. The B horizon is a plastic, compact, gray to drab clay loam, spotted and stained with rusty red iron concretions.

Management.—Drainage is the first requirement in managing this type. Outlets are difficult to secure. In some areas alkali is present and they should be treated with potash salts and with applications of strawy manure if the land is farmed. At the present time this type is utilized almost exclusively for pasture.

Deep Peat (1401)

Deep Peat occupies only 2.06 square miles in the county and occurs in small areas. The two largest areas are found in DuPage and Washington townships (Townships 37 North, Range 10 East, and 33 North, Range 15 East).

The surface 6 or 8 inches is a well-disintegrated black peat, with no fibrous material remaining. Immediately below this surface layer, a brown, fibrous peat occurs, ranging from 35 or 40 inches to 6 or 7 feet in depth. The peat rests on a drab to black clay. Drainage has been provided in certain areas of this type by laying boards in the ditches and placing the tile upon the boards so as to keep the tile in alignment.

Management.—Nearly all the areas of peat are properly drained and are under cultivation. Peat is usually deficient in potassium and this deficiency can be corrected by the application of one of the potash salts at the rate of about 100 pounds an acre. (See results from the Manito field, page 60.)

Medium Peat On Clay (1402)

Medium Peat On Clay occupies a total of only 64 acres in Will county. The type occurs in the vicinity of the Deep Peat areas and in some of the kettle holes in the morainic region.

The surface, extending to a depth of 6 or 8 inches, is a well-decomposed peat, brown to black in color. Below this depth undecomposed brown peat occurs which rests on a somewhat sticky, compact, drab silty clay or clay.

Management.—Nearly all the areas of the type have a slightly alkaline reaction. The subsoil is of such nature that open ditches can be constructed and maintained. Practically all the Medium Peat On Clay is under cultivation. In areas where the alkali is sufficiently concentrated to be harmful, its bad effects can be corrected as was recommended above for Black Mixed Loam.

Peaty Loam (1410)

The only area of Peaty Loam in Will county is located in Township 32 North, Range 9 East, Section 22. It covers an area of 71 acres. The type is high in organic matter and nitrogen. The drainage of this area is only fair because of the flat topography and poor outlet.

The surface 6 or 7 inches varies from a well-disintegrated peaty loam, black in color, to a black sandy loam rich in organic matter. Below this depth a black sandy loam occurs; the sand particles themselves are white. At about 16 to 18 inches an incoherent mass of gray sand occurs.

Management.—Proper drainage is the first problem to consider in improving this type. Alkali is present and the potash treatment, as recommended for Black Mixed Loam, page 28, is the remedy to employ for this difficulty. It should not be applied, however, until after the poor drainage has been corrected.

Medium Peat On Rock (1402.5)

Medium Peat On Rock occurs in areas of Mixed Loam On Rock (1454.5) along DesPlaines river. The type occupies only 32 acres. The deposits occur as poorly drained areas in the depressions of the limestone bed rock and are subject to continued seepage of drainage water. Many hummocks occur in the areas. The drainage is very poor.

This material varies from a partially decomposed, fibrous, black peat to a black muck, which extends to a depth of 6 to 14 inches, depending on the contour of the limestone rock. This type has no agricultural value other than as pasture.

RESIDUAL SOILS (099)

Numerous limestone outcrops, mapped as Residual Soils, occur in Will county. There are eight quarries with shipping facilities in the vicinity of Joliet. The stone occurring in this region is dolomitic and is, for the most part, of high purity. In addition to the quarries with shipping facilities, there are a number of local quarries and numerous outcrops, particularly along the DesPlaines river valley, which may serve as a source of agricultural limestone.

Information regarding the composition of the stone from most of these quarries and for many of the outcrops can be secured from the State Geological Survey, Urbana, Illinois, or from the Agricultural Experiment Station.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items which may assist in the differentiation of types, but which are not fundamental to it, are native vegetation (whether timber or prairie), topography, and geological origin and formation.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a matured soil, three horizons designated as A, B, and C are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the A horizon.

C designates the layer lying below the B horizon and in which the material has been less affected by the weathering processes.

Frequently differences within these strata or zones are discernible, in which case they are subdivided and described under such designations as A_1, and A_2, B_1, and B_2, etc.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in differentiating soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state

800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* formed by material derived from the Illinoisan or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged Glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, crop-

ping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain...	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw...	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain....	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover....	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs.....	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.....	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oats straw.....	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed....	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay....	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed ..	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay...	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay....	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5.

[2]Young second-year growth ready to plow under as green manure.

[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning

recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4, have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.

1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, acid phosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate, and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as

sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average livestock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached

out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of

crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before

the crop is planted. Whether the crop is corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the better adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to those Occurring in Will County)

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system. Some modifications have been introduced in recent years.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grain to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated (aP = acid phosphate, bP = bonemeal, rP = rock phosphate, sP = slag phosphate)
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
Le = Legume used as green manure
Cv = Cover crop
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed
| = Heavy vertical rule, indicating the beginning of complete treatment
|| = Double vertical rule, indicating a radical change in the cropping system

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

THE JOLIET FIELD

A University soil experiment field is located in Will county about three miles northwest of Joliet on the Lincoln highway. This field has been in operation

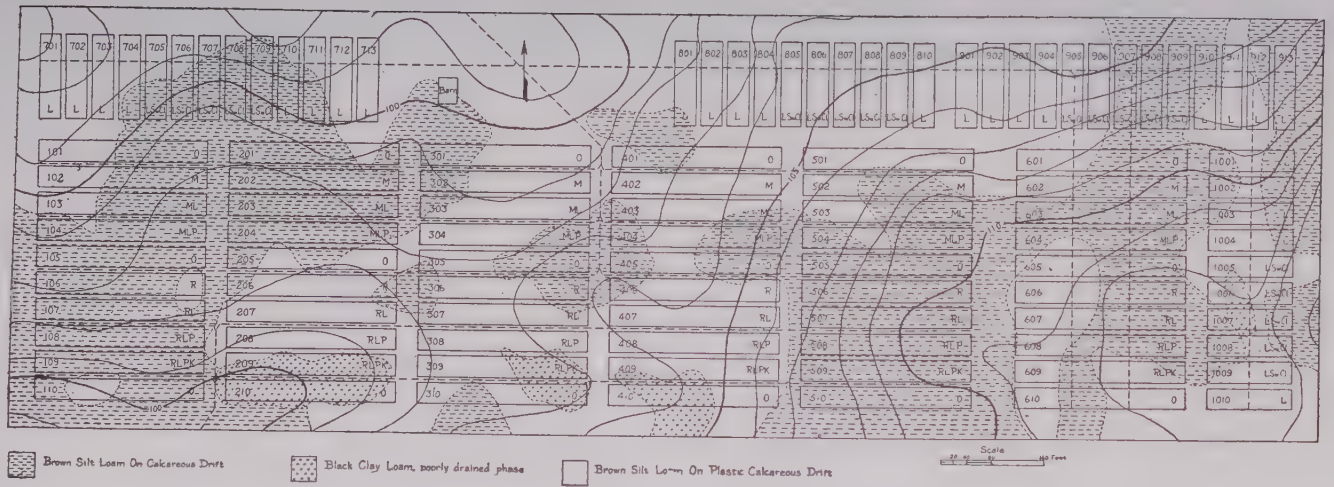
Brown Silt Loam On Calcareous Drift
Black Clay Loam, poorly drained phase
Brown Silt Loam On Plastic Calcareous Drift
Scale

FIG. 2.—DIAGRAM OF JOLIET EXPERIMENT FIELD

This diagram shows the arrangement of plots, the soil treatments applied, the location of the different soil types, and by means of contour lines, the natural drainage of this field.

since 1914. It comprizes 31 acres of prairie soil of loessial and drift origin and shown on the county map as Brown Silt Loam. Based upon certain distinctions in soil profile, however, the Brown Silt Loam may be resolved here into two separable types, Brown Silt Loam On Calcareous Drift and Brown Silt Loam On Plastic Calcareous Drift. Besides these there are present some small patches of Black Clay Loam of the poorly drained phase. The distribution of these soil types, as well as the arrangement of plots, is charted in the accompanying diagram (Fig. 2). The topography of the surface is indicated on the diagram by contour lines.

The field is laid out into two separate systems of plots, each system with its own program of crop rotation and under the various soil treatments, as indicated on the diagram and in the tables which follow.

Series 100 to 600

The original rotation on Series 100 to 600 inclusive was corn, oats, clover, wheat, and soybeans, with alfalfa on the sixth series for six years. In 1921 this rotation was changed to corn, corn, oats, clover, and wheat, with a seeding of sweet clover on the residues plots, and alfalfa on the sixth series for six years. Since 1921 all clover has been removed as hay. In 1921 the return of the oat straw was discontinued, as was also the wheat straw the following year. The application of limestone was likewise discontinued in 1922, to be resumed when need for more lime becomes apparent.

A record of yields of all crops produced on these series is given in Table 7, but for convenience in considering the results these records are summarized in Table 8, in which is shown the average annual yields of the several crops, including the years since the complete soil treatments have been in effect.

In looking over these results, one may observe first a beneficial effect of animal manure on all crops but a most pronounced effect on the corn. This suggests the importance of carefully conserving and regularly applying all available stable manure. Residues alone have produced some increase in the corn, but have had little effect on the yield of other crops.

Where limestone is applied there has usually been some increase in yield. Limestone has been especially beneficial to alfalfa.

Very marked crop increases have followed the application of rock phosphate, so that the use of this material has proved exceedingly profitable on this field.

Profitable response to potassium, in the combination here used, has been secured only in the corn and wheat, so that considering the rotation as a whole, the value of crop increase has not been sufficient to cover the cost of material. Perhaps a smaller amount of the kainit, applied directly to the corn, would return a financial profit.

Series 700 to 1000

The plots now comprizing Series 700, 800, 900, and 1000 were not subdivided until 1921. Series 700 and 800 had been used for a wheat-legume-alfalfa combination, while Series 900 and 1000 had been used for a wheat-legume-timothy combination. This land had all received 2½ tons of limestone an acre without

TABLE 7.—JOLIET FIELD: SERIES 100–600
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1914 Wheat[1]	1915 Soy-beans[2]	1916 Corn	1917 Oats	1918 Soy-beans	1919 Wheat	1920 Alfalfa seeding	1921 Oats[3]	1922 Alfalfa	1923 Alfalfa	1924 Alfalfa	1925 Alfalfa
101	0	16.5	(1.42)	18.1	73.4	(1.13)	28.2	.....	46.7	(1.50)	(1.63)	(1.12)	(.82)
102	M	19.3	(1.50)	29.4	80.1	(1.33)	32.5	.....	45.9	(1.81)	(1.79)	(1.70)	(1.44)
103	ML	20.9	(1.68)	34.0	79.4	(1.32)	35.0	.....	50.8	(2.32)	(2.42)	(2.57)	(2.36)
104	MLrP	21.5	(1.82)	33.4	83.1	(1.53)	39.8	.....	51.4	(2.79)	(3.32)	(3.49)	(3.29)
105	0	18.2	15.2	18.5	70.2	18.8	19.4	.....	41.1	(1.24)	(1.59)	(1.39)	(.55)
106	R	19.9	14.0	18.9	73.8	18.7	23.8	.....	43.3	(1.26)	(1.46)	(1.15)	(.67)
107	RL	20.8	15.8	21.6	73.8	21.2	26.6	.....	47.7	(1.80)	(1.75)	(1.93)	(1.74)
108	RLrP	20.2	15.2	25.0	80.5	23.2	33.6	.....	51.9	(2.73)	(3.51)	(4.21)	(3.61)
109	RLrPK	22.0	16.3	25.1	70.5	23.6	33.8	.....	52.3	(2.82)	(3.54)	(4.03)	(3.46)
110	0	17.4	15.1	18.6	75.5	(1.17)	32.3	.....	46.6	(1.49)	(1.68)	(1.70)	(.54)
		Clover[1]	Wheat[2]	Soy-beans[2]	Corn	Oats	Clover	Wheat	Corn	Corn	Oats	Clover	Wheat
201	0	(2.00)	9.8	(.55)	7.3	75.2	(1.59)	22.6	31.4	28.8	58.9	(1.40)	10.3
202	M	(2.05)	7.9	(.59)	7.9	69.4	(1.67)	33.6	31.7	35.0	67.7	(2.27)	10.7
203	ML	(1.97)	14.3	(.66)	10.4	72.0	(1.60)	36.4	35.5	39.7	63.1	(2.46)	16.2
204	MLrP	(2.02)	20.3	(.63)	14.3	75.2	(1.73)	46.5	39.2	45.4	66.4	(2.82)	24.4
205	0	(1.91)	10.6	8.2	6.0	76.2	1.45	31.7	31.5	31.8	60.2	(1.75)	8.0
206	R	.42	15.6	7.9	7.7	76.9	.29	32.7	38.2	36.9	62.0	(1.56)	7.9
207	RL	1.00	20.0	8.9	11.1	76.7	.54	33.2	45.3	40.5	61.1	(2.00)	14.8
208	RLrP	.92	24.9	11.5	14.6	82.2	.75	47.4	48.6	46.5	71.3	(3.13)	31.8
209	RLrPK	1.83	30.4	15.0	23.4	87.8	.62	48.3	50.7	54.9	67.2	(3.67)	39.2
210	0	1.25	25.2	(1.06)	23.7	81.1	(1.64)	23.8	37.0	35.0	59.4	(2.31)	22.0

[1]Lime only. [2]No manure. [3]Nurse crop for alfalfa seeding in 1921.

TABLE 7.—JOLIET FIELD: SERIES 100–600—*Continued*

Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1914 Oats[1]	1915 Soy-beans[2]	1916 Wheat[2]	1917 Soy-beans[2]	1918 Corn	1919 Oats	1920 Soy-beans	1921 Wheat	1922 Corn	1923 Corn	1924 Oats	1925 Clover
301	0	60.9	10.6	4.1	(1.58)	27.2	35.3	(1.64)	30.4	29.0	36.9	56.6	(.49)
302	M	60.2	(1.42)	5.2	(1.66)	57.2	48.0	(1.62)	33.3	32.7	46.8	60.3	(.63)
303	ML	59.8	(1.69)	8.3	(1.67)	56.3	51.7	(1.81)	40.7	44.4	56.5	63.6	(.90)
304	MLrP	59.5	(1.75)	7.9	(1.78)	59.2	50.6	(1.88)	44.3	45.4	57.2	63.3	(1.13)
305	0	50.2	13.9	6.0	9.4	34.5	37.7	9.4	25.6	23.9	33.1	56.6	(.35)
306	R	53.3	13.0	9.9	8.8	33.2	38.6	9.4	26.9	37.0	45.0	53.9	(.53)
307	RL	60.8	13.7	13.2	8.2	45.6	44.2	11.8	28.5	43.0	54.9	68.8	(.57)
308	RLrP	59.1	15.1	18.7	11.5	55.6	49.2	14.1	37.9	50.9	61.5	76.1	(1.41)
309	RLrPK	68.8	15.0	15.2	12.6	60.2	49.7	15.4	42.9	57.9	68.2	70.9	(1.37)
310	0	52.5	12.8	7.1	(1.39)	38.8	35.0	(1.60)	28.5	23.8	32.4	53.1	(.39)
		Corn[1]	Oats[2]	Clover[2]	Wheat[2]	Soy-beans[2]	Corn	Oats	Clover	Wheat	Corn	Corn	Oats
401	0	44.7	72.5	(1.17)	8.2	(1.26)	28.1	57.3	(.63)	25.9	35.4	36.2	30.2
402	M	46.9	73.0	(1.24)	10.3	(1.35)	32.6	67.5	(.70)	30.4	53.6	41.1	39.1
403	ML	52.4	70.5	(1.16)	10.9	(1.21)	39.5	69.5	(.75)	32.7	57.9	45.2	38.8
404	MLrP	50.2	75.0	(1.64)	19.6	(1.53)	44.3	93.1	(1.13)	38.8	66.1	52.4	50.5
405	0	42.3	67.7	.33	9.8	18.6	29.0	59.8	(.55)	26.6	36.7	35.6	36.1
406	R	50.6	62.8	.42	8.8	18.6	39.0	61.7	(.66)	27.1	49.9	34.0	41.7
407	RL	53.2	63.4	.50	13.4	19.2	41.8	62.5	(.86)	29.1	50.1	40.7	44.8
408	RLrP	51.0	65.0	.50	22.5	23.3	42.9	72.5	(1.29)	39.3	57.4	44.2	53.9
409	RLrPK	53.1	72.0	.42	24.3	22.6	44.4	71.7	(1.31)	40.7	63.0	49.5	53.8
410	0	45.1	63.1	(1.15)	0.0	(1.63)	29.2	58.6	(.75)	27.3	36.7	38.2	30.9

[1]Lime only. [2]No manure.

TABLE 7.—JOLIET FIELD: SERIES 100–600—*Concluded*

Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1914 Soy-beans[1]	1915 Corn	1916 Oats	1917 Soy-beans	1918 Wheat	1919 Soy-beans	1920 Corn	1921 Oats	1922 Clover	1923 Wheat	1924 Corn	1925 Corn
501	0	(1.24)	28.6	70.9	(1.60)	19.8	(.67)	32.8	62.2	(1.44)	16.8	34.2	34.6
502	M	(1.40)	36.3	75.9	(1.74)	21.5	(.88)	48.6	70.3	(1.90)	20.0	44.8	39.0
503	ML	(1.51)	38.3	77.2	(1.84)	31.0	(.94)	51.1	66.4	(1.70)	22.5	49.6	49.9
504	MLrP	(1.28)	47.7	77.7	(1.87)	39.9	(1.06)	48.9	69.1	(2.10)	30.8	55.8	54.3
505	0	12.1	28.5	73.3	10.9	22.0	9.2	36.2	58.3	(1.18)	14.1	34.3	38.4
506	R	11.9	32.4	71.1	11.0	28.8	9.2	46.0	61.1	(1.28)	11.8	37.2	40.4
507	RL	13.3	28.7	63.9	11.0	27.0	12.2	42.8	59.2	(1.46)	16.8	39.9	44.8
508	RLrP	11.9	31.2	59.8	13.4	35.4	14.0	47.4	68.4	(1.88)	28.9	56.6	50.4
509	RLrPK	14.8	43.4	81.4	14.7	39.9	13.3	51.3	69.7	(2.14)	36.5	54.6	56.2
510	0	(1.12)	27.1	74.1	(1.50)	20.8	(.67)	34.5	60.8	(1.30)	11.4	31.2	35.6
		Alfalfa seeding[1]	Alfalfa[3]	Alfalfa[3]	Alfalfa[3]	Alfalfa[3]	Soy-beans[3]	Soy-beans[3]	Corn	Oats	Clover	Wheat	Corn
601	0	.....	(1.79)	(1.46)	(.44)	(1.55)	(.81)	(1.94)	49.4	53.3	(.32)	19.6	42.5
602	M	.....	(2.13)	(1.78)	(.47)	(1.64)	(.74)	(1.97)	51.2	56.1	(.71)	27.3	55.1
603	ML	.....	(2.83)	(2.96)	(.81)	(2.52)	(1.25)	(1.97)	52.6	60.0	(.81)	28.9	56.5
604	MLrP	.....	(3.73)	(4.35)	(1.28)	(2.99)	(1.13)	(2.07)	50.7	60.8	(1.02)	38.4	56.6
605	0	.....	(2.18)	(2.16)	(.71)	(2.01)	(.89)	16.2	51.8	58.4	(.41)	25.9	46.8
606	R	.....	(2.57)	(2.23)	(.74)	(2.06)	(1.12)	16.7	46.1	53.6	(.51)	27.8	54.1
607	RL	.....	(2.90)	(2.88)	(.97)	(2.30)	(1.18)	16.2	53.2	61.9	(.64)	25.7	53.9
608	RLrP	.....	(3.39)	(4.10)	(1.28)	(2.42)	(1.23)	15.7	54.5	62.2	(.83)	37.0	55.0
609	RLrPK	.....	(3.56)	(4.38)	(1.46)	(2.56)	(1.15)	16.2	53.0	63.3	(.91)	37.5	56.9
610	0	.....	(1.90)	(1.72)	(.41)	(1.30)	(.86)	(1.68)	51.5	55.5	(.30)	17.9	45.0

[1]Lime only. [2]No manure. [3]No residues or manure.

FIG. 3.—ALFALFA ON THE JOLIET EXPERIMENT FIELD

Here are shown the products of two plots both receiving crop residues. Without limestone and rock phosphate, the yield of hay was 1.46 tons an acre. With these materials applied to the land, the yield was 3.51 tons an acre.

further soil treatment. In 1921 it was plotted and put under a rotation of corn, barley, soybeans, and wheat. Hubam clover has been seeded on Plots 5, 6, 7, 8, and 9 in the barley, and biennial sweet clover on the same plots in the wheat. In 1924 another modification was made in the cropping plan, the rotation now being corn, barley, wheat, and legumes (red clover being seeded in the wheat on Plots 1, 2, 3, and 4 on all series and on Plots 11, 12, and 13 on Series 700 and 900, and alfalfa seeded on Plots 5, 6, 7, 8, 9, and 10). The following soil treatments were applied: an additional 8,000 pounds an acre of limestone to Plot 7 on all series; rock phosphate at the annual acre-rate of 400 pounds to Plots 2, 3, 6, 7, and 8; acid phosphate at the acre-rate of 250 pounds ahead of the wheat

TABLE 8.—JOLIET FIELD: Series 100-600, SUMMARY OF CROP YIELDS

Average Annual Yields 1915-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *16 crops*	Oats *11 crops*	Wheat *8 crops*	Clover[1] *6 crops*	Soy-beans *4 crops*	Alfalfa *4 crops*
1	0	31.3	56.4	21.7	(.98)	(1.26)	(1.27)
2	M	40.2	61.8	26.2	(1.31)	(1.39)	(1.69)
3	ML	44.8	63.2	30.4	(1.37)	(1.48)	(2.42)
4	MLrP	48.2	67.4	37.9	(1.66)	(1.59)	(3.21)
5	0	32.3	57.1	21.7	(.95)	12.1	(1.19)
6	R	37.3	58.0	23.3	(.81)	12.1	(1.14)
7	RL	41.1	60.4	25.2	(1.01)	14.1	(1.81)
8	RLrP	46.4	66.2	36.4	(1.55)	16.2	(3.52)
9	RLrPK	50.8	67.0	39.9	(1.67)	16.8	(3.46)
10	0	33.6	57.3	23.0	(1.12)	(1.14)	(1.35)
	M over 0	8.9	5.4	4.5	(.33)	(.13)	(.42)
	R over 0	5.0	.9	1.6	−(.14)	.00	−(.05)
	ML over M	4.6	1.4	4.2	(.06)	(.09)	(.73)
	RL over R	3.8	2.4	1.9	(.20)	2.0	(.67)
	MLrP over ML	3.4	4.2	7.5	(.29)	(.11)	(.79)
	RLrP over RL	5.3	5.8	11.2	(.54)	2.1	(1.71)
	RLrPK over RLrP	4.4	.8	3.5	(.12)	.6	−(.06)

[1]One crop of seed on Plots 6, 7, 8, and 9 is evaluated as hay.

TABLE 9.—JOLIET FIELD: SERIES 700, 800, 900, 1000
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1921 Corn[1]	1922 Barley[1]	1923 Soybeans[1]	Soil treatment as modified	1924 Wheat	1925 Soybeans
701	L	48.6	23.8	15.2	LeL	29.5	(1.85)
702	L	55.0	32.1	18.8	LeLrP	28.3	(2.03)
703	L	52.4	26.7	15.0	LeLrPGyp	28.7	(1.72)
704	L	45.6	26.7	16.2	LeL	27.0	(1.70)
705	LeL	41.0	24.6	14.7	LeL	26.7	(1.63)
706	LeL	48.4	29.8	18.7	LeLrP	29.0	(1.82)
707	LeL	45.2	28.3	16.2	LeLrP	27.5	(1.81)
708	LeL	42.0	23.5	14.7	LeLrPKCl	22.7	(1.71)
709	LeL	52.0	25.2	17.2	LeLKCl	19.5	(1.80)
710	L	51.6	27.7	18.0	LeL	19.5	(1.69)
711	L	56.8	29.0	19.8	LeL	17.5	(2.16)
712	L	53.0	24.4	21.2	LeLaP	19.7	(1.46)
713	L	49.2	24.4	18.5	LeLaP	26.2	(1.49)
		Wheat[1,2]	Corn	Barley		Barley	Wheat
801	L	.....	33.0	31.5	LeL	17.9	8.3
802	L	.....	39.8	37.7	LeLrP	16.3	14.0
803	L	.....	47.6	42.3	LeLrPGyp	18.8	16.7
804	L	.....	34.0	35.6	LeL	14.8	9.8
805	LeL	.....	37.0	35.8	LeL	16.0	10.2
806	LeL	.....	35.8	34.8	LeLrP	17.3	12.0
807	LeL	.....	42.2	38.8	LeLrP	17.1	14.3
808	LeL	.....	43.8	40.4	LeLrPKCl	18.1	16.5
809	LeL	.....	43.8	42.3	LeLKCl	17.9	21.0
810	L	.....	39.2	42.7	LeL	21.7	21.8
		Corn[1]	Wheat[3]	Corn		Corn	Barley
901	L	48.8	.....	40.6	LeL	31.8	23.5
902	L	49.6	.....	55.4	LeLrP	46.8	24.4
903	L	53.4	.....	58.2	LeLrPGyp	49.0	22.1
904	L	47.6	.....	49.0	LeL	48.4	21.9
905	LeL	49.0	.....	52.0	LeL	48.0	19.8
906	LeL	53.8	.....	54.4	LeLrP	42.2	23.5
907	LeL	50.8	.....	53.4	LeLrP	49.6	23.8
908	LeL	50.2	.....	46.4	LeLrPKCl	46.4	17.7
909	LeL	45.4	.....	45.4	LeLKCl	41.0	18.1
910	L	54.0	.....	53.6	LeL	38.4	23.5
911	L	62.2	.....	58.8	LeL	48.6	23.5
912	L	52.4	.....	51.8	LeLaP	46.0	21.0
913	L	54.8	.....	52.8	LeLaP	46.0	17.1
		Wheat[1]	Soybeans[1]	Wheat[3]		Soybeans	Corn
1001	L	27.7	13.5	.....	LeL	15.0	40.0
1002	L	28.2	13.8	.....	LeLrP	15.7	46.8
1003	L	31.3	15.7	.....	LeLrPGyp	18.2	51.2
1004	L	32.0	15.3	.....	LeL	17.3	47.2
1005	LeL	30.2	14.5	.....	LeL	18.2	47.0
1006	LeL	32.2	15.7	.....	LeLrP	18.2	49.6
1007	LeL	29.5	15.7	.....	LeLrP	17.2	46.4
1008	LeL	29.0	14.8	.....	LeLrPKCl	14.5	50.0
1009	LeL	31.2	17.0	.....	LeLKCl	15.5	51.6
1010	L	29.3	11.8	.....	LeL	15.3	40.0

[1]No legume treatment. [2]All plots harvested together. [3]Crop failure.

crop on Plots 12 and 13; potassium chlorid at the annual acre-rate of 100 pounds to Plots 8 and 9; and gypsum at the annual acre-rate of 100 pounds to Plot 3.

A discussion of the results of the work on these series is scarcely warranted at this time since the experiments of any one system are of such short duration. The crop yields are reported in Table 9, however, as a matter of record, and future developments on these plots will be watched with interest.

THE HARTSBURG FIELD

The results of experiments on the Hartsburg field are introduced as representing the soil type Black Clay Loam, poorly drained phase. This field is located in Logan county just east of Hartsburg. The work began in 1911. The field was laid off into five series of 10 plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series after which it was changed to corn, corn, oats, and wheat on four of the series and to corn, oats, wheat, and an alfalfa and red clover mixture on the fifth series. The soil treatments are as indicated in Table 10. The table summarizes by crops, the yields for the period during which the plots have been under full treatment.

The outstanding feature of these results is the large increase in yields produced by residues, which even exceeds the increase brought about by the use of stable manure.

The behavior of limestone on this field is rather peculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure, limestone shows some increase in all crops, while with residues the effect on several of the crops appears negative.

Altho rock phosphate has given some increases in wheat yield in both manure and residues systems, the results with other crops have been such as to render the use of this material unprofitable on this field.

The addition of potassium appears to have produced no significant effect upon the yields of any of the crops.

It may be mentioned that new experiments have recently been started on these plots which are designed to answer some of the questions brought out by

TABLE 10.—HARTSBURG FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1913-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn[1] *17 crops*	Oats *13 crops*	Wheat *11 crops*	Clover[2] *6 crops*	Soy-beans *2 crops*	Alfalfa[3] *10 crops*
1	0	46.7	47.6	25.6	(2.19)	(1.29)	(3.47)
2	M	56.6	53.0	30.1	(2.59)	(1.65)	(3.67)
3	ML	62.9	58.7	35.6	(2.67)	(1.82)	(3.91)
4	MLrP	61.5	58.6	38.1	(2.80)	(1.93)	(4.19)
5	0	52.6	46.2	30.9	(1.48)	25.8	(3.33)
6	R	62.6	54.9	34.1	(1.91)	26.8	(3.78)
7	RL	66.9	53.0	31.3	(1.82)	28.5	(3.45)
8	RLrP	65.8	57.4	35.3	(1.97)	26.2	(4.04)
9	RLrPK	65.2	56.7	34.7	(1.89)	26.5	(4.16)
10	0	52.7	48.3	31.6	(2.35)	(1.69)	(3.20)
	M over 0	9.9	5.4	4.5	(.40)	(.36)	(.20)
	R over 0	10.0	8.7	3.2	(.43)	1.0	(.45)
	ML over M	6.3	5.7	5.5	(.08)	(.17)	(.24)
	RL over R	4.3	−1.9	−2.8	−(.09)	1.7	−(.33)
	MLrP over ML	−1.4	− .1	2.5	(.13)	(.11)	(.28)
	RLrP over RL	−1.1	4.4	4.0	(.15)	2.3	(.59)
	RLrPK over RLrP	− .6	− .7	− .6	−(.08)	.3	(.12)

[1]One corn crop without residues. [2]One crop of stubble clover included; some seed evaluated as hay on Plots 5, 6, 7, 8, and 9. [3]No residues for the first 6 crops.

the foregoing results. For example, the effect of applying phosphorus in other carriers and in different combinations, as well as testing the residual effect of phosphate already applied, will be tried.

THE ANTIOCH FIELD

The Antioch field is located in Lake county close to the Wisconsin border. The land is slightly rolling and the soil is of the type designated as Yellow-Gray Silt Loam On Calcareous Drift. The field was started in 1902. The work is now confined to a single series of 10 plots.

The rotation first established was corn, corn, oats, and wheat, but in 1911 this was changed to wheat, corn, oats, and clover. Nitrogen was applied in the earlier years in 800 pounds of dried blood an acre a year, but after 1911 the use of commercial nitrogen was discontinued and crop residues and legumes were substituted. Phosphorus was supplied in 200 pounds of steamed bone meal. In 1924 rock phosphate was applied as additional treatment to Plots 2, 3, and 5, which formerly had received no phosphorus. Potassium sulfate has been used mainly as the source of potassium. At the beginning, slaked lime was applied at the rate of 470 pounds an acre. No more lime was used until 1912, when a 2-ton application of limestone was made. This was followed by a 3-ton application in 1918.

The results are presented in Table 11, which is so arranged as to show first a summary, by averages, of the several crops grown from the beginning up to 1923, and second, the annual results of the three different crops obtained since the rock phosphate application in 1924. On account of an abnormality in Plot 1 the results from this plot are vitiated to some extent.

The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. After bone meal had demonstrated repeatedly this highly beneficial effect, the question arose as to whether the necessary phosphorus could be efficiently supplied on this soil thru the use of rock phosphate. Accordingly rock phosphate was applied to plots which hitherto had not received bone meal. Altho the experiments have not continued long enough for a final test of the relative efficiency of these two phosphorus carriers, the results indicate very favorable effects upon crop yields by the use of rock phosphate. The rock phosphate was first applied in the spring of 1924 in preparing the land for oats. As might be expected, no immediate effect on the oat crop is apparent. In the following year, however, the clover shows a marked response to the phosphate treatment. In considering these clover yields it should be noted that on the residue plots only one crop of hay is harvested, the second crop being plowed under for soil improvement; on all other plots the results represent the combined yields of the first and second crops.

The wheat in 1926 likewise shows a marked response to the rock phosphate treatment. Altho the yields of the newly treated rock phosphate plots are not quite so high as those of the corresponding bone meal plots, it is possible that the latter are at some advantage due to the cumulative effects of the many years of previous phosphatic treatment.

Potassium sulfate as applied in these experiments has not given very consistent results, but, on the whole, it appears that the use of potassium fertilizer

TABLE 11.—ANTIOCH FIELD: CROP YIELDS
Bushels or (tons) per acre

Plot No.	Soil treatment applied	Average annual grain yields 1902-1923			Additional treatment applied in 1924	Annual yields 1924-1926		
		Wheat *5 crops*	Corn *9 crops*	Oats *5 crops*		Oats 1924	Clover[1] 1925	Wheat 1926
1	0.....	14.7	24.5	32.3	....	17.5	(2.37)	26.5
2	L.....	13.3	21.8	26.8	+ rP	25.3	(4.11)	41.3
3	LR.....	18.9	22.5	29.9	+ rP	24.7	(2.69)	44.3
4	LbP.....	35.0	31.0	43.6	....	26.9	(4.51)	48.5
5	LK.....	17.8	23.3	27.8	+ rP	13.1	(4.27)	44.3
6	LRbP...	32.6	34.1	43.3	....	28.4	(3.16)	52.2
7	LRK....	19.2	25.4	26.9	....	20.3	(2.31)	31.7
8	LbPK...	30.3	26.1	38.2	....	30.6	(4.60)	49.3
9	LRbPK .	28.1	38.9	42.6	....	27.8	(2.58)	51.5
10	RbPK...	31.0	38.7	44.7	....	26.6	(2.86)	48.8

[1]Red clover mixed with some volunteer growth of sweet clover. Figures represent the combined yields of first and second crops except on residues plots, where only the first crop is harvested.

on this kind of soil and in this kind of farming does not represent a profitable practice.

The results are also unfavorable for lime. Limestone, however, is abundant in the substrata of this soil type.

Lime applied and residues plowed under

Lime and phosphorus applied

FIG. 4.—CLOVER ON THE ANTIOCH EXPERIMENT FIELD

These pictures illustrate the beneficial effect of phosphorus on the Antioch field. The land at the left has received no phosphorus fertilizer, altho lime has been applied and residues plowed under. That at the right has been treated with bone meal as well as with lime.

THE OQUAWKA FIELD

In 1913 the University established an experiment field on Dune Sand, Terrace, in Henderson county, near the Mississippi river. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

Table 12 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 48.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been greatly increased. The limestone has also produced good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite unresponsive to treatment with rock phosphate. The analyses show, however, that the stock of phosphorus in this type of soil is not large. As time goes on and the supply diminishes along with the production of good-sized crops, it may be that the application of this element will become profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

Altho the results show an increase of nearly three bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment. The slight apparent effects in the other crops are scarcely significant.

TABLE 12.—OQUAWKA FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields, 1915-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *11 crops*	Soybeans[1] *11 crops*	Wheat *11 crops*	Sweet Clover[2] *7 crops*	Rye *9 crops*	Alfalfa *8 crops*
1	0	19.8	(1.01)	7.7	0.00	11.9	(.35)
2	M	25.0	(1.20)	10.9	0.00	13.3	(.56)
3	ML	32.2	(1.60)	14.6	1.14	24.5	(2.05)
4	MLrP	31.9	(1.58)	15.0	1.14	23.0	(2.12)
5	0	20.1	(.78)	9.8	0.00	11.7	(.08)
6	R	21.8	(.76)	11.1	0.00	12.7	(.09)
7	RL	36.7	(1.25)	13.9	1.57	24.3	(1.82)
8	RLrP	36.1	(1.25)	14.1	1.43	24.3	(1.79)
9	RLrPK	39.0	(1.17)	13.3	1.67	26.5	(1.87)
10	0	19.1	(.72)	8.8	0.00	10.7	(.02)
	M over 0	5.2	(.19)	3.2	0.00	1.4	(.21)
	R over 0	1.7	−(.02)	1.3	0.00	1.0	(.01)
	ML over M	7.2	(.40)	3.7	1.14	11.2	(1.49)
	RL over R	14.9	(.49)	2.8	1.57	11.6	(1.73)
	MLrP over ML	−.3	−(.02)	.4	0.00	− 1.5	(.07)
	RLrP over RL	−.6	(.00)	.2	− .14	....	−(.03)
	RLrPK over RLrP	2.9	−(.08)	−.8	.24	2.2	(.08)

[1]Eleven regular crops, together with the extra crop described in Footnote 2, are averaged as 11 crops. Several crops which were harvested as seed are evaluated in this summary as hay.

[2]Some hay is here evaluated as seed. In 1918 the sweet clover was killed by early cutting for a hay crop; soybeans were seeded in July, and the ensuing crop is included in the soybean averages.

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 5.—ALFALFA ON THE OQUAWKA EXPERIMENT FIELD

These pictures show the possibility of improving this unproductive sandy land on the Oquawka field. Both plots were seeded alike to alfalfa. Where manure alone was applied, the crop was a total failure, but where limestone in addition to manure was applied, nearly 4½ tons of alfalfa hay was obtained as the season's yield.

A significant fact which the above summary does not bring out is that improvement under favorable treatment has been progressive, as evidenced by a very marked upward trend in production after the first few years. For example, the acre yields under the limestone-residues treatment for the entire 11-year period are: corn, 36.7 bushels; wheat, 13.9 bushels; and rye, 24.3 bushels, but if we take the corresponding averages for the last five years the yields are: corn, 45.7 bushels; wheat, 19.6 bushels; and rye, 25.2 bushels.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

THE MANITO FIELD

The results secured on the Manito experiment field which was located on Deep Peat and which was in operation during the years 1902 to 1905, inclusive, are presented in Table 13.

There were ten plots receiving the treatments indicated in the table. Where potassium was applied, the yield was from three to four times as large as where

nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. However, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the total yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) appear to be insufficient.

TABLE 13.—MANITO FIELD: ANNUAL CORN YIELDS

Bushels per acre

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905
1	None	10.9	8.1	None	17.0	12.0
2	None	10.4	10.4	Limestone, 4000 lbs	12.0	10.1
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs. Kainit, 1200 lbs	49.6	47.3
4	Kainit, 600 lbs. Acidulated bone, 350 lbs	30.3	33.3	Kainit, 1200 lbs. Steamed bone, 395 lbs.	53.5	47.6
5	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs	44.5	47.3
8	Kainit, 600 lbs	36.8	37.7	Kainit, 600 lbs	44.0	46.0
9	Kainit, 300 lbs	26.4	25.1	Kainit, 300 lbs	41.5	32.9
10	None	[1]	14.9	None	26.0	13.6

[1]No yield was taken in 1902 because of a misunderstanding.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1925
33 Saline, 1926
34 Marion, 1926
35 Will, 1926

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 36

WOODFORD COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER,
AND L. H. SMITH

URBANA, ILLINOIS, JUNE, 1927

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Woodford county was conducted, and Mr. F. A. Fisher who, as leader of the field party, was in direct charge of the mapping.

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WOODFORD COUNTY SOILS

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WOODFORD COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

LOCATION AND CLIMATE OF WOODFORD COUNTY

Woodford county is located in the north-central part of Illinois. It is a medium-sized county, covering 531.62 square miles, the major portion of which is made up of dark-colored upland soil.

The climate of Woodford county is typical of the general region in which it lies. It is characterized by a wide range between the extremes of winter and summer and by an abundant, well-distributed rainfall. The greatest range in temperature for any one year from 1913 to 1924 is 127 degrees in 1914. The highest temperature recorded was 107° in 1916; the lowest, 24° below zero in 1924. The average date of the last killing frost in the spring is May 4; the earliest in the fall, October 10. The average length of the growing season is 159 days.

The average annual rainfall as recorded at Minonk from 1913 to 1924 was 32.03 inches. The average rainfall by months for this period was as follows: January, 1.28 inches; February, 1.16; March, 2.29; April, 3.11; May, 3.89; June, 4.24; July, 2.80; August, 3.81; September, 3.33; October, 2.66; November, 1.79; December, 1.67.

AGRICULTURAL PRODUCTION

Woodford county is one of the leading agricultural counties of the state. Slightly over 65 percent of the area of the county is productive, dark-colored soil, making it a typical corn-belt county. According to the Fourteenth Census of the United States, there were 1900 farms in the county in 1919. The number of farms shows a decrease of about 12 percent during the last two decades. In 1919 about 54 percent of the farms were operated by tenants. There has been practically no change in the percentage of tenancy in the county during the last two decades.

The principal crops are corn and oats with an increasing acreage of the clovers and alfalfa. The following table shows the acreage and yield of the more important crops for 1919.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	94,802	4,112,186 bu.	43.4 bu.
Oats	72,524	2,235,263 bu.	30.8 bu.
Wheat	16,488	320,314 bu.	19.4 bu.
Rye	2,080	25,040 bu.	12.0 bu.
Timothy	4,325	5,912 tons	1.37 tons
Timothy and cloved mixed	5,573	8,125 tons	1.46 tons
Clover	8,140	12,084 tons	1.48 tons
Alfalfa	790	2,148 tons	2.72 tons
Silage crops	1,298	9,568 tons	7.37 tons

[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

The U. S. Department of Agriculture reports the following average acre yields for the ten-year period 1911-1920: corn, 40.7 bushels; oats, 41.1 bushels; tame hay, 1.22 tons; winter wheat, 21.0 bushels. Thus it appears that the season of the Census year 1919 was fairly representative for the principal crops except for the oats, the yield of 30.8 bushels given for this crop being far too low to represent the average.

Woodford county gives more attention to grain farming than to livestock. The following figures taken from the 1920 Census show the character of the livestock interests in Woodford county.

Animals and Animal Products	*Number*	*Value*
Horses	13,593	$1,348,978
Mules	542	62,500
Beef cattle	13,371	787,089
Dairy cattle	11,722	728,740
Sheep	4,436	60,926
Swine	39,309	821,149
Poultry	219,793	204,177
Eggs and chickens	.....	520,028
Dairy products	.....	255,855

SOIL FORMATION

GEOLOGICAL ASPECTS

One of the most important periods in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during which and immediately following, the material that later formed the mineral portion of the soils was being deposited. During the Glacial period, great ice sheets moved southward from the centers of accumulation in Labrador, in the Hudson Bay region, and in the northern Rocky mountains. At least six great ice movements took place, each of which covered a part of northern United States, altho the same parts were not covered during each advance.

Two of these great glacial advances, the Illinoisan and early Wisconsin, covered the area that now constitutes Woodford county. The glacial debris, known as till or drift, deposited by the Illinoisan ice sheet, was buried by the debris deposited by the more recent early Wisconsin ice sheet. Altho the Illinoisan drift does not enter into the composition of the soils of Woodford county, yet the Illinoisan glaciation probably had an important relation to the agricultural value of the soils of this county in that it acted as a leveling force, rubbing down the preglacial hills and filling the preglacial valleys. Information collected by the State Geological Survey from the few well borings available indicates that the drift extends to a depth of 125 to 150 feet over most of the county.

The soils of Woodford county are of glacial origin. Those in the northeastern part of the county are derived largely from glacial till and are known as drift soils, while those in the western and southern part of the county are derived from loess and are known as loessial soils.

The separation between the loess and drift areas can be indicated by a general line starting just north of Kappa, taking a westerly and northerly direction, swinging around to the east and north of Secor, then taking a northwesterly direction, swinging around south and west of Cazenovia, and then taking a

northeasterly direction, leaving the county at about the center of Section 6, Township 28 North, Range 1 East. This line of separation between the loess and drift areas is not shown on the soil map but can readily be sketched in from the above delineation.

There is a close relation between the width of the bottom land along the Illinois river and the depth and extent of the loess on the adjacent upland. In the northwest corner of the county, the Illinois bottom is wide and to the east of this tract the loess is deeper than anywhere else in the county, reaching a depth of over 11 feet in the region of Washburn. In the vicinity of Metamora, the loess is about 8 feet deep and it gradually thins out to about 5 feet in depth in the region of Secor, Congerville, and Kappa. The extension of the loess to the eastward in the southern part of the county is apparently associated with the bottom land along the Mackinaw river and the extensive terrace formation in southern Tazewell and northern Mason counties.

The character of the soil has been strongly influenced by the character of its parent material. That a difference between the loess and drift areas exists is evident even to the casual observer from the difference in sweet clover growth along the roadsides. Carbonates occur at a depth of 30 to 40 inches in the drift area, while in the loess area no effervescence with acid occurs until a depth of from five to six feet is reached. The subsoil in the loess area is much more permeable than in the drift area, and the lime material was in a much more finely divided condition at the time the soil material was deposited, consequently leaching took place more rapidly and has progressed to a greater depth.

Limestone Outcrops

Altho a consideration of the rock formation does not lie within the province of this soil survey report, a bit of information concerning the presence of available limestone in Woodford county is inserted at this point because of its direct agricultural interest.

According to Bulletin No. 46 of the Illinois State Geological Survey, limestone of Pennsylvanian age is reported as occurring in Woodford county as follows:

Three feet of compact stone occur about 4 miles northwest of Metamora in Section 1, Township 27 North, Range 3 West, along Partridge creek.

Limestone 8 to 12 feet thick, bluish gray in color, may be found in a small quarry southwest of Secor in Sections 23 and 24, Township 26 North, Range 1 East.

Stone similar to preceding is found in a small quarry in Section 33, Township 26 North, Range 1 East.

PHYSIOGRAPHY AND DRAINAGE

The general topography of the upland in Woodford county is undulating. Rolling topography is found only in belts along the main drainage channels, and on the moraines, particularly on the Bloomington moraine which crosses the southwestern part of the county. Erosion has caused the rolling topography along streams. The slopes are steep near the Illinois river bluff, and in places along the Mackinaw river channel. The topography in the terrace area is undulating, except for the rolling sand dune formations. The altitudes of some of the places

FIG. 1.—DRAINAGE MAP OF WOODFORD COUNTY SHOWING STREAM COURSES, AND MORAINAL, INTERMORAINAL, TERRACE, SWAMP, AND BOTTOM-LAND AREAS

in Woodford county are as follows: Benson, 765 feet above sea level; Cazenovia, 774; El Paso, 751; Eureka, 739; Goodfield, 748; Kappa, 773; Metamora, 814; Minonk, 745; Roanoke, 722; Secor, 744; Spring Bay, 490; Washburn, 695. The Illinois river valley lies some 200 feet below the general upland level.

The entire county lies in the Illinois river basin. The central and eastern parts of the county do not drain directly into the river, however. Drainage in the northeastern corner of Minonk township (Township 28 North, Range 2 East) is northeast to Vermilion river, thence north to the Illinois. The central and southern parts of the county are drained by Mackinaw river thru its two main tributaries, Walnut and Panther creeks. Mackinaw river flows southwest, emptying into the Illinois about 30 miles south of the county.

There were many shallow ponds, swamps, and poorly drained areas in the central and eastern parts of the county prior to its settlement. Artificial drainage, principally tiling and deepening of the small ditches, removed this excess water so that now these areas can be farmed. Except for the swampy overflow land next to Illinois river, both the surface drainage and underdrainage of the whole county are good.

SOIL DEVELOPMENT

During the time which has elapsed since the last ice invasion, weathering and other processes have been active, resulting in the formation of the soils of the county as we know them today. When first deposited the general composition of any soil material, particularly loess, is rather uniform but with the passing

of time various physical chemical, and biological agencies of weathering form soil out of the parent material by some or all of the following processes: the leaching of certain elements, the accumulation of others; the chemical reduction of certain compounds, the oxidation of others; the translocation of the finer soil particles, and the arrangement of them into zones, or "horizons"; the accumulation of organic matter from the growth and decay of vegetable material. One of the very pronounced characteristics observed in most soils is that they are composed of more or less distinct strata, called horizons. As explained somewhat more fully in the Appendix, these horizons are named, from the surface down: A, the layer of extraction; B, the layer of concentration or accumulation; and C, less-altered material, or the layer in which weathering has had less effect. The development of horizons in a soil is an indication of its age.

Since the upland prairie of this region has been occupied, probably continuously, by grass vegetation, relatively large amounts of organic matter have accumulated, resulting in the formation of productive dark-colored soils. The areas adjacent to streams, which have been occupied by timber, are light-colored because of the relative deficiency of the surface soil in organic matter. The bottom-land soils are made up, for the most part, of alluvial material brought down from the uplands of the immediate vicinity. These soils are to be regarded as relatively young or immature and therefore have not developed horizons as have the mature soils of the upland.

SOIL GROUPS

The soils of Woodford county are divided into four groups, as follows:

Upland Prairie Soils, including the dark-colored upland soils.

Upland Timber Soils, including the light-colored upland soils.

Swamp and Bottom-Land Soils, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

Terrace Soils, including alluvial deposits now above overflow.

Table 1 gives the area of each soil type in Woodford county and its percentage of the total area. It will be observed that 66.32 percent of the county consists of upland prairie, 22.29 percent of upland timber, 1.79 percent of terrace soils, 6.53 percent of bottom-land soils, and 3.09 percent grouped as miscellaneous, including river, swamp, mine dumps, and gravel pits. The accompanying map, appearing in two sections, shows the location and boundary lines of the various soil types.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix to this report.

TABLE 1.—SOIL TYPES OF WOODFORD COUNTY, ILLINOIS

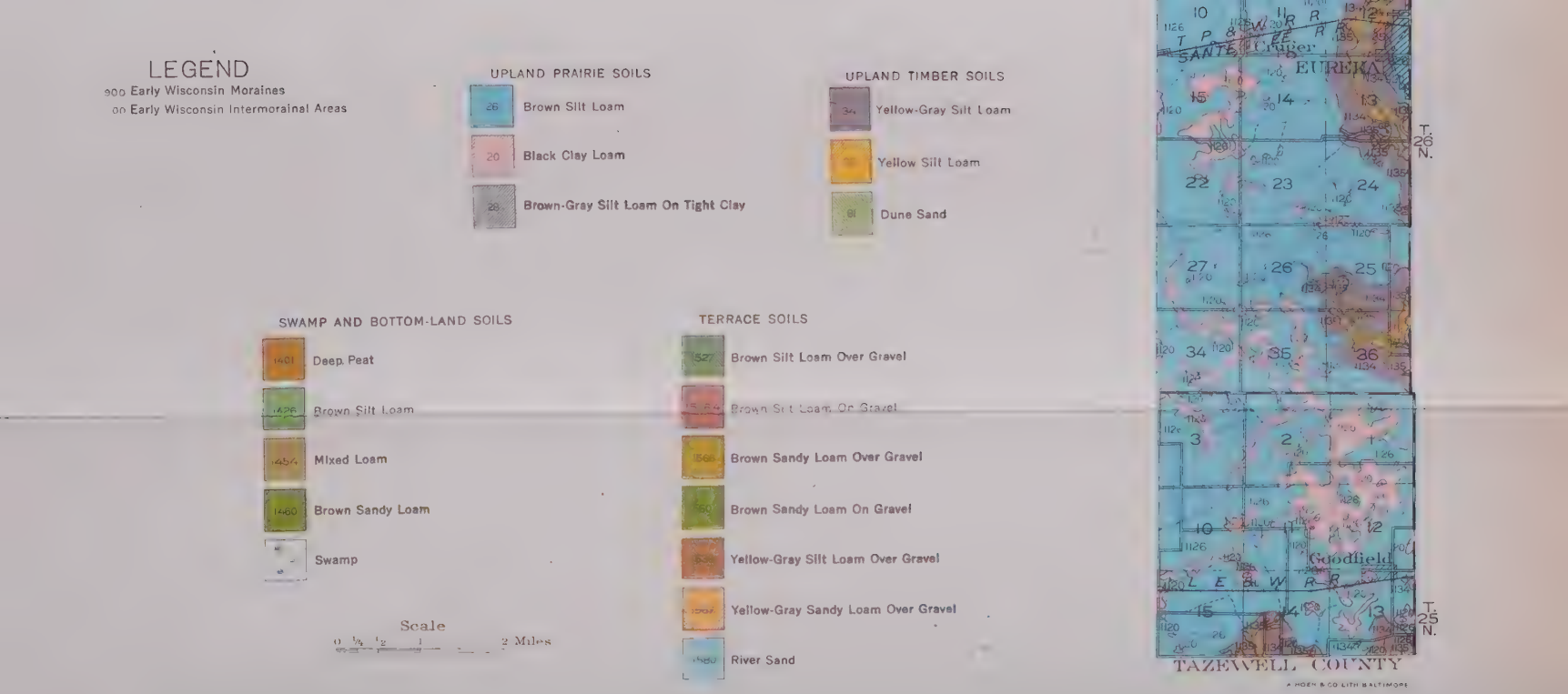
Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils (900, 1100)			
926, 1126	Brown Silt Loam[1]	310.29	198 586	53.38
920, 1120	Black Clay Loam	42.29	27 066	7.95
1128	Brown-Gray Silt Loam On Tight Clay	.04	26	.01
		352.62	225 678	66.32
	Upland Timber Soils (900, 1100)			
934, 1134	Yellow-Gray Silt Loam	67.86	43 430	12.77
935, 1135	Yellow Silt Loam	49.58	31 731	9.31
1181	Dune Sand	.97	621	.18
		118.41	75 782	22.29
	Swamp and Bottom-Land Soils (1400)			
1401	Deep Peat	.60	384	.11
1426	Brown Silt Loam	2.29	1 465	.42
1454	Mixed Loam	31.76	19 607	5.98
1460	Brown Sandy Loam	.11	70	.02
		34.76	22 246	6.53
	Terrace Soils (1500)			
1527	Brown Silt Loam Over Gravel	2.22	1 421	.42
1526.4	Brown Silt Loam On Gravel	.15	96	.02
1566	Brown Sandy Loam Over Gravel	.20	128	.04
1560.4	Brown Sandy Loam On Gravel	1.79	1 146	.33
1536	Yellow-Gray Silt Loam Over Gravel	2.87	1 837	.54
1567	Yellow-Gray Sandy Loam Over Gravel	.48	307	.09
1580	River Sand	1.70	1 088	.33
		9.41	6 023	1.77
	Miscellaneous			
	River	7.53	4 819	1.42
	Swamp	8.84	5 657	1.66
	Mine Dumps	.03	19	.006
	Gravel pits	.02	13	.004
		16.42	10 508	3.09
	Total	531.62	340 237	100.00

[1] Including associated types described in the text but not differentiated on the map.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN WOODFORD COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). These sampling strata correspond approxi-

R.3 W
MARSHALL COUNTY
R.2 W
Sugar Creek
Washburn
ILLINOIS RIVER
Richland Creek
Low Point
ALTON AND CHICAGO R.R.
Cazenovia
Pourtrayer Creek
Spring Bay
Metamora
T. 28 N.
T. 27 N.



SOIL SURVEY MAP OF WOODFORD COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

mately in the common kinds of soil to 2 million pounds per acre of dry soil in the upper stratum, and to two times and three times this quantity in the middle and lower strata, respectively. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to in describing the soil types as horizons A, B, and C (see page 24). By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed. It should be understood, however, that the rate of liberation from their insoluble forms, a matter of at least equal importance, is governed by many factors, and is therefore not necessarily proportional to the total amounts present.

For convenience in making application of the chemical analyses, the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In doing this, the assumption is made that for ordinary types a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2 million pounds. It is understood, of course, that this value is only an approximation, but it is believed that with this understanding, it will suffice for the purpose intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires to consider the information in that form.

With respect to the presence of limestone and acidity in different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages for the respective types, because of the extreme variations frequently found within a given soil type. In examining each soil type in the field, however, numerous qualitative tests are made which furnish general information regarding the soil reaction, and in the discussion of the individual soil types which follow, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping and soil treatment. It is often desirable, therefore, to determine the lime requirement for a given field, and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (page 31).

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amounts of organic carbon, nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil of each type in Woodford county.

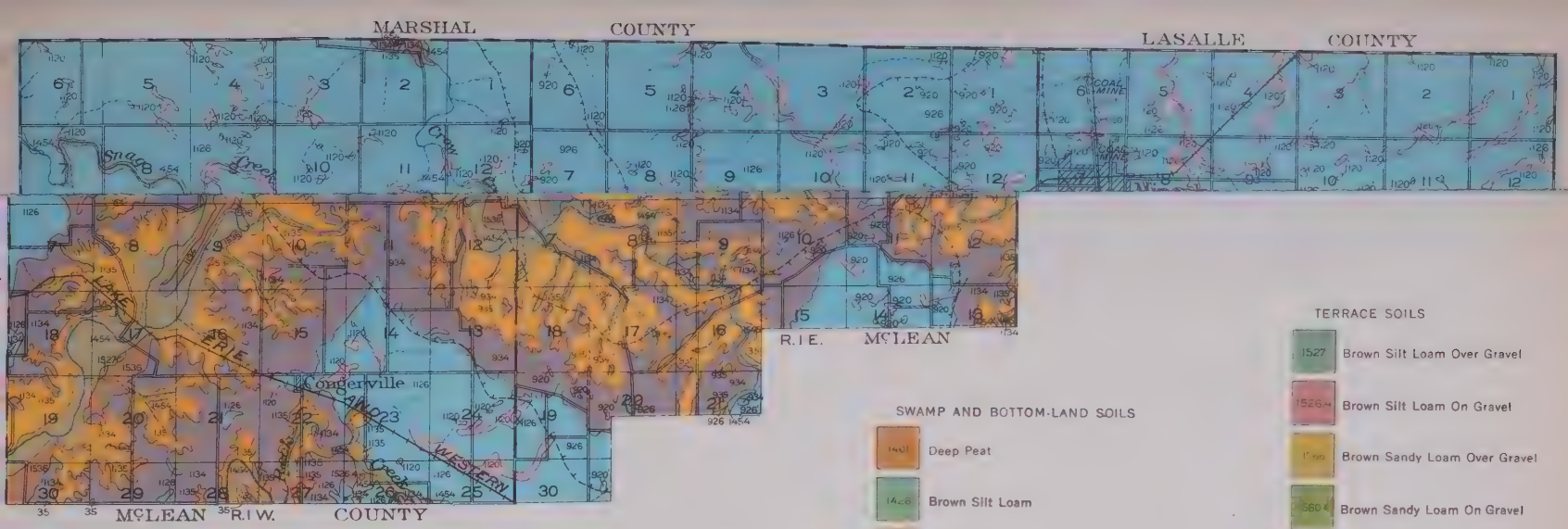
In connection with this table attention is called to the variation among the soil types with respect to their content of the different plant-food elements. It will be seen from the analyses that variations in the organic-carbon content of the different soils are accompanied by similar variations in the nitrogen content. The organic carbon content, which serves as a measure of the total organic matter present, is usually from 10 to 12 times that of the total nitrogen. This relationship is explained by the well-established facts that all soil organic matter contains nitrogen, and that most of the soil nitrogen (usually 98 percent or more) is present in a state of organic combination. This close relationship is also maintained in the middle and lower sampling strata.

Woodford county soils have a wide range in content of organic-matter and nitrogen. The upland prairie soils are for the most part relatively high in these constituents. The upland timber soils are generally fairly low, whereas the swamp, bottom-land, and terrace soils show extreme variations. The sand soils are the lowest of all, regardless of where they occur. Thus the upland Dune Sand contains but 5,480 pounds an acre of organic carbon and 680 pounds of nitrogen. The River Sand of the terrace is somewhat higher in organic carbon, but is much below the types of finer texture. Dune Sand is, in fact, but little more than the skeleton of a soil and cannot by any practical means be brought up to a state of productiveness without first getting an accumulation of organic matter in it, and continuing with subsequent additions. The soil is usually acid and hence limestone and legume green manures constitute the first and most important step in converting it into a productive soil.

Black Clay Loam has more organic carbon in the upper layer than any other soil in the county except Deep Peat, which is made up largely of organic matter. The organic carbon of the Black Clay Loam amounts to 82,510 pounds an acre, with a corresponding nitrogen content of 7,070 pounds. While such soils as this will withstand more abuse by the practice of "soil robbing" methods of farming and are not so greatly in need of additions of organic materials as are soils containing 20,000 to 30,000 pounds of organic carbon, yet the use of manure and the systematic growing of legumes for pasture and plowing down serve to renew the active organic material in the soil in a way which is reflected in increases of crop yields. Excluding Dune Sand, discussed above, the upland timber soils of Woodford county average only 26,260 pounds of organic carbon and 2,260 pounds of nitrogen an acre in the surface 2 million pounds of soil, as compared with 62,850 and 5,170 pounds of these two elements respectively in the upland prairie soils.

Other constituents are not so closely associated with each other as organic matter and nitrogen. However, there is some degree of correlation between sulfur, another element used by growing plants, and organic carbon. This is because a considerable, tho varying, proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of the organic matter.

Most of the Woodford county soils are fairly well supplied with sulfur. It ranges, in the surface soil, from the very low figure of 160 pounds to 5,900 pounds an acre. With the exception of Deep Peat, which contains a very large amount of sulfur, the sulfur content amounts to between one-half and two-thirds that of phosphorus. The sulfur available to crops is affected not only by the soil supply,



LEGEND

Early Wisconsin Moraines

Early Wisconsin Intermorainal Areas

UPLAND PRAIRIE SOILS

- 26 Brown Silt Loam
- 20 Black Clay Loam
- 28 Brown-Gray Silt Loam On Tight Clay

UPLAND TIMBER SOILS

- 34 Yellow-Gray Silt Loam
- 35 Yellow Silt Loam
- 81 Dune Sand

SWAMP AND BOTTOM-LAND SOILS

- 1401 Deep Peat
- 1426 Brown Silt Loam
- 1454 Mixed Loam
- 1460 Brown Sandy Loam
- Swamp

TERRACE SOILS

- 1527 Brown Silt Loam Over Gravel
- 1526A Brown Silt Loam On Gravel
- 1580 Brown Sandy Loam Over Gravel
- 1580A Brown Sandy Loam On Gravel
- 1536 Yellow-Gray Silt Loam Over Gravel
- Yellow-Gray Sandy Loam Over Gravel
- 1580 River Sand

Scale

0 ½ 1 2 Miles

SOIL SURVEY MAP OF WOODFORD COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

but also by that brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently it is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption the amount of sulfur thus added to the soil is relatively large. At Urbana, during the eight-year period from 1917 to 1924, there was added to the soil by the rainfall, 3.5 pounds of sulfur an acre as a monthly average. Similar observations have been made in other localities for shorter periods. At Carlinville, in Macoupin county, the rainfall for seven months, April to October, 1922, brought down 34.85 pounds of sulfur an acre, or an average of 5 pounds a month. At Toledo, Cumberland county, from April to November, 1922, the average precipitation was 3 pounds an acre a month. The precipitation at the various points in the state in a single month has varied from a minimum of .74 of a pound to 10.22 pounds an acre.

The above figures will afford some idea of the amount of sulfur added by rain and also of the wide variation in these amounts under different conditions. On the whole, these facts would indicate that the sulfur added from the atmosphere supplements that contained in the soil, so that for the most part there is probably no need for sulfur fertilizers in Woodford county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started at five experimental fields; namely, Raleigh, Toledo, Carthage, Hartsburg, and Dixon.

The upland timber soils are deficient in phosphorus, the amounts in the surface soil ranging from 320 pounds to 800 pounds per 2 million pounds of soil. River Sand and Yellow-Gray Silt Loam Over Gravel in the terrace are likewise deficient. These deficiencies would indicate the probable need for phosphate fertilization on these soils, as mentioned in the discussion of these types. The rest of the soil types in the county are fairly well supplied with total phosphorus.

Deep Peat, as is usually the case, is deficient in potassium, there being only 6,880 pounds in the surface 6⅔-inch stratum. Other types, excepting Dune Sand and River Sand, contain rather more potassium than is usually the case, the average, eliminating these low types, being 44,530 pounds per 2 million pounds of soil. The sand soils, while containing a total amount of potassium which should be sufficient for crop production, carry a large proportion of it in the coarse sand grains. The relatively small surface exposed in the case of the coarse particles greatly lowers the solubility and availability of the potassium in sand soils. This is partly offset, however, by the greater depth of the feeding zone for crop roots in sandy soils as compared with the heavier types.

Both calcium and magnesium are fairly well supplied in the soils of Woodford county. The supply of calcium in the upper 6⅔ inches of soil ranges from 5,920 to 72,170 pounds, and the supply of magnesium from 2,340 to 18,860 pounds.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper stratum, or with each other, it is necessary to bear in mind that the data as given

for the middle and lower sampling strata are on the basis of 4 million and 6 million pounds of soil, and should therefore be divided by two and three respectively before comparing them with each other or with the data for the upper stratum, which is on a basis of 2 million pounds.

Considering the data in this way and comparing the three strata with each other, it will be noted that some of the elements remain practically constant in amount thruout the entire depth sampled. Others exhibit more or less marked variation at the different levels. Furthermore, these variations usually go in certain general directions, and by a careful study of them it is frequently possible to obtain clues as to the age or stage of maturity of the various soils, the agricultural importance and needs, and the nature of the processes going on in soil formation.

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF WOODFORD COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (900, 1100)							
926, 1126	Brown Silt Loam	57 410	4 450	1 020	1 410	43 440	7 240	10 730
1120	Black Clay Loam	82 510	7 070	2 030	1 400	45 770	11 250	39 810
1128	Brown-Gray Silt Loam On Tight Clay	48 640	3 980	1 000	680	50 920	6 030	10 680
	Upland Timber Soils (900, 1100)							
934, 1134	Yellow-Gray Silt Loam	29 900	2 530	800	610	48 450	4 860	9 170
1135	Yellow Silt Loam	22 620	1 990	690	380	51 010	8 160	13 820
1181	Dune Sand	5 480	680	320	180	31 420	9 540	6 520
	Swamp and Bottom-Land Soils (1400)							
1401	Deep Peat[1]	309 860	27 700	1 020	5 900	6 880	6 330	72 170
1426	Brown Silt Loam	49 240	4 180	1 680	600	51 340	18 860	27 820
1454	Mixed Loam[2]							
1460	Brown Sandy Loam	27 180	2 280	1 220	320	39 600	15 980	30 500
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	51 730	4 030	1 490	790	44 780	8 010	11 010
1526.4	Brown Silt Loam On Gravel	33 200	2 720	1 300	620	34 800	6 820	9 270
1566	Brown Sandy Loam Over Gravel	24 120	2 040	700	400	44 740	4 260	8 800
1560.4	Brown Sandy Loam On Gravel	42 240	3 790	1 580	870	31 900	8 620	9 830
1536	Yellow-Gray Silt Loam Over Gravel	21 580	1 800	730	360	40 260	3 960	7 360
1580	River Sand	10 620	760	460	160	29 960	2 340	5 920

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]Amounts reported for Deep Peat are for 1 million pounds of soil.

[2]On account of the heterogeneous character of Mixed Loam, chemical data are not included for this type.

With the exception of Deep Peat all of the soil types diminish rather rapidly in organic matter and nitrogen with increasing depth, and this diminution is very marked even in the middle stratum. The sulfur content decreases markedly with increasing depth except in the case of Deep Peat. This is to be expected since a portion of the sulfur exists in combination with the soil organic matter, and inorganic forms of sulfur are not tenaciously retained by the soil against the leaching action of ground water. Phosphorus, on the other hand, is not removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in these forms in plant residues at the expense of the underlying strata. Consequently, in the majority of the soil types in Woodford county the surface soil contains a larger proportionate amount of phosphorus than the middle and lower strata.

The content of potassium in the different depths varies only slightly, but the other two important basic elements, calcium and magnesium, have undergone some shifting in the different levels, as exhibited by analyses of upland types. The calcium content, on the whole, is much higher than that of magnesium, indicating a more abundant supply of calcium in the soil-forming materials. However, with the exception of Yellow Silt Loam, which is alkaline in the middle and

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF WOODFORD COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (900, 1100)							
926, 1126	Brown Silt Loam	74 980	6 430	1 620	1 360	85 540	18 320	21 340
1120	Black Clay Loam	83 400	7 300	3 100	1 420	98 330	23 700	52 770
1128	Brown-Gray Silt Loam On Tight Clay	52 520	4 560	1 520	880	104 880	18 400	20 440
	Upland Timber Soils (900, 1100)							
934, 1134	Yellow-Gray Silt Loam	24 640	2 560	1 420	780	102 750	14 080	15 760
1135	Yellow Silt Loam	21 420	2 400	1 510	710	93 910	21 170	52 080
1181	Dune Sand	7 440	760	960	520	64 680	6 080	12 080
	Swamp and Bottom-Land Soils (1400)							
1401	Deep Peat[1]	790 300	62 200	1 620	16 760	10 340	9 420	138 760
1426	Brown Silt Loam	100 080	8 440	3 440	1 360	105 400	36 440	50 920
1454	Mixed Loam[2]	.....	.....	.....	.....	.....	.....	.....
1460	Brown Sandy Loam	37 080	3 280	2 120	520	69 760	39 040	83 960
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	71 010	6 130	2 590	1 060	93 960	19 980	19 980
1526.4	Brown Silt Loam On Gravel	49 600	4 380	2 260	1 040	69 420	16 140	18 260
1566	Brown Sandy Loam Over Gravel	46 400	4 000	1 160	960	78 880	9 800	20 080
1560.4	Brown Sandy Loam On Gravel	66 210	4 900	2 120	1 240	66 730	17 100	15 450
1536	Yellow-Gray Silt Loam Over Gravel	22 760	2 180	1 460	620	87 140	14 540	15 240
1580	River Sand	16 720	1 200	1 040	440	55 240	6 040	12 040

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Amounts reported for Deep Peat are for 2 million pounds of soil.

[2]On account of the heterogeneous character of Mixed Loam, chemical data are not included for this type.

lower strata, carrying considerable quantities of calcium carbonate, the calcium content diminishes in the middle stratum as compared with the upper. This is accompanied by an increase in the magnesium content in both the middle and lower strata. As these two elements leach downward thru the soil, magnesium is more readily absorbed by the soil mass than calcium, thus forcing the latter out into the solution to be carried farther down. Consequently calcium does not begin to accumulate until it reaches the lowest level, and in counties farther south, with greater rainfall, it is carried down several feet or washed away entirely. The terrace soils are beginning to show the results of this process, but in the bottom-land soils these changes are completely masked by the effects of overflow.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is not possible to obtain this information exactly, especially for the deeper rooted crops, it seems probable that practically all the feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil type the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF WOODFORD COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (900, 1100)							
926, 1126	Brown Silt Loam	40 260	3 750	2 020	970	136 290	42 330	44 440
1120	Black Clay Loam	31 250	3 450	3 560	1 020	148 430	39 360	63 950
1128	Brown-Gray Silt Loam On Tight Clay	33 900	3 720	2 760	780	169 680	43 860	37 980
	Upland Timber Soils (900, 1100)							
934, 1134	Yellow-Gray Silt Loam	25 500	2 490	2 270	920	153 810	37 070	28 500
1135	Yellow Silt Loam	21 440	2 240	2 180	1 020	131 760	54 080	162 700
1181	Dune Sand	7 380	840	1 500	660	81 300	10 560	15 780
	Swamp and Bottom-Land Soils (1400)							
1401	Deep Peat[1]	1 351 050	9 000	1 890	41 100	19 500	15 300	168 180
1426	Brown Silt Loam	74 700	6 360	4 140	1 260	146 460	73 680	119 100
1454	Mixed Loam[2]	.....	.....	.....	.....	.....	.....	.....
1460	Brown Sandy Loam	30 000	2 100	2 400	900	110 880	48 420	121 680
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	58 600	5 180	3 440	1 110	138 040	42 000	30 180
1526.4	Brown Silt Loam On Gravel	54 780	5 340	3 480	2 040	97 740	42 660	28 320
1566	Brown Sandy Loam Over Gravel	36 660	3 000	1 800	840	139 560	19 980	19 200
1560.4	Brown Sandy Loam On Gravel	43 510	3 720	2 400	1 200	88 800	17 700	23 540
1536	Yellow-Gray Silt Loam Over Gravel	22 920	2 100	2 490	780	121 230	21 780	22 680
1580	River Sand	13 260	1 320	840	420	81 340	4 320	21 060

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Amounts reported for Deep Peat are for 3 million pounds of soil.

[2]On account of the heterogeneous character of Mixed Loam, chemical data are not included for this type.

Examined in this way the tables reveal that there is not only a wide diversity among the different soils with respect to a given plant-food element, but that there is also a great variation with respect to the relative abundance of the various elements within a given soil type as measured by crop requirements. For example, in the analyses as given for Brown Silt Loam, Upland, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 14,630 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus, 4,660 pounds, contained in the same soil is equivalent to that contained in 27,410 bushels of corn, while the amount of potassium present is 265,270 pounds, the equivalent of that contained in nearly 1½ million bushels of corn. In marked contrast to this soil, with respect to nitrogen, is the Yellow Silt Loam, which contains in the 40-inch stratum approximately 6,630 pounds an acre of nitrogen, an amount equal to that in 6,630 bushels of corn. The phosphorus content is about the same as that of Brown Silt Loam, namely, 4,380 pounds in an acre, equivalent to that contained in 25,760 bushels of corn. The potassium content of the two soil types is also approximately equal. The calcium content is not of so much significance in connection with corn as with legumes. Brown Silt Loam contains in the 40-inch stratum 76,510 pounds of calcium an acre, while Yellow Silt Loam contains 228,600 pounds. Since a ton of red clover hay contains approximately 29 pounds of calcium the above amounts are equivalent, respectively, to 2,640 and 7,950 tons of clover hay. This wide variation in amounts of calcium in the two soil types is accounted for by the presence of calcium carbonate in the lower sampling stratum of Yellow Silt Loam, while in Brown Silt Loam it has been leached out to a depth greater than 40 inches. As a matter of fact, since the carbonate in the soil is largely calcium carbonate, soils showing the presence of carbonate invariably contain large quantities of calcium. For example, it has been found in examining the individual analyses of Woodford county soils that the non-carbonate soils range in calcium content from 34,000 pounds an acre up to 78,000 pounds, in the 40-inch stratum, while with the carbonate-containing soils the range is from 47,000 pounds to 592,000 pounds. Only two samples, however, fell below the 78,000-pound level.

The above statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration, aside from merely the amount of plant-food elements present in the soil. Much depends upon the nature of the crops to be grown, as to their utilization of plant-food materials, and much depends upon the condition of the plant-food substances themselves as to their availability. Finally, in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon, and in this way contribute fundamental information for the intelligent planning, in a broad way, of systems of soil management for conserving and improving the fertility of the land.

DESCRIPTION OF SOIL TYPES

The soil map upon which this report is based was completed in 1917. During the years which have elapsed since the survey was made, the knowledge of soils has increased very materially, particularly with reference to soil classification. At the present time several of the types shown on the map, notably Brown Silt Loam, Black Clay Loam, and Yellow-Gray Silt Loam, are each considered to include two or more types. For the purposes of this report, these types, which are now recognized but not shown on the map, will be described and their topographic position stated so that they may be recognized in the field.

UPLAND PRAIRIE SOILS

The upland prairie soils of Woodford county occupy 352.62 square miles, or 66.32 percent of the area of the county.

The dark color of prairie soils is due to the accumulation of organic matter, which is derived very largely from the fibrous roots of prairie grasses. The network of grass roots was protected from rapid and complete decay owing to the rather effective exclusion of oxygen by the covering of fine, moist soil, and by the mat of vegetative material formed by old grass stems and leaves. On the native prairies the stems and leaves of the grasses were in part burned by prairie fires or were lost in part thru decay, so that they actually added little organic matter to the soil; however, the protection afforded by this mat of constantly renewed, decaying material was of importance in retarding the decay of the roots. From a sample of virgin bluestem sod, one of the most common prairie grasses, it has been determined that an acre of this soil to a depth of 7 inches may contain as high as 13½ tons of roots.

Brown Silt Loam (926, 1126)

Brown Silt Loam, Upland, as mapped, is the most extensive type in Woodford county. The portion of the type found in the loess area, as described in the section on Geological Aspects (page 2) is markedly different from that found in the drift area. In the loessial portion of the type it is much deeper to carbonate, averaging 60 to 70 inches as compared with 30 to 40 inches in the drift area; the B horizon is less mottled, and less compact and heavy; and the C horizon is a very friable, fine sandy loam, while in the drift area it is a compact sandy and gravelly clay. The A horizon of Brown Silt Loam in the two areas, loess and drift, is not significantly different, at least in so far as characteristics which can be observed in the field are concerned.

Types of the Loess Area

In the loess area, the soil which was mapped originally as Brown Silt Loam is now separated into three types, as follows: Light Brown Silt Loam, Brown Silt Loam, and Brown Silt Loam On Clay.

Light Brown Silt Loam occurs on the higher areas and has always been well drained. The A_1 horizon, which is about 10 to 12 inches deep, is a light brown silt loam. The A_2 horizon, which extends to a depth of about 20 to 22 inches,

is a slightly yellowish brown silt loam. The B horizon is a non-mottled, non-compact, reddish yellow silt loam or silty clay loam, and the C horizon is a very friable, slightly mottled, fine sandy loam, passing into highly calcareous fine sandy loam at about 60 inches.

Management.—This type is similar to the soil of a considerable portion of the Mt. Morris experiment field. On this field, manure alone has given excellent returns, and when limestone has been applied in addition to the manure, a further increase has resulted, which has been sufficiently large to pay a handsome profit on the limestone. Residues alone have increased the yields of corn and oats, but the data from this field indicate clearly that if residues and green manures are used as the chief source of nitrogen and organic matter on this soil, limestone must also be included in the system. The crop increases following the use of limestone and green manure are large, exceeding the increases following the use of stable manure and limestone. Rock phosphate has not caused sufficient increase in yield on the Mt. Morris field to pay for its cost. The reader is referred to page 42 for a further discussion of the results from this field. The available information indicates that, for the present at least, Light Brown Silt Loam should be treated with 2 to 3 tons of limestone an acre followed by the regular growth of clover, preferably sweet clover, and the application of all available manure. It is suggested that, in addition, trial be made of the phosphates for wheat. A discussion of the various phosphates will be found in the Appendix on page 34.

Brown Silt Loam occurs on positions of intermediate topographic expression. The A_1 horizon, about 10 inches deep, is a brown silt loam, passing into a somewhat heavier, light brown silt loam which frequently becomes reddish brown at about 14 inches. The B horizon begins at 20 to 22 inches, and extends to 28 to 33 inches in depth. It is a medium-mottled, yellow or yellowish brown clay loam, medium compact, and only slightly plastic. The C horizon is a mottled, pale yellow, friable silt loam with reddish brown iron concretions, and passes into fine sandy loam which becomes highly calcareous at about 60 inches.

Management.—This type is similar to the soil on the Kewanee experiment field. The results from this field (page 43) show a good response to manure alone and to residues and lime in combination. Where lime was used in addition to manure, an additional increase in yield was secured, but the increase was not so large as where lime was used in addition to residues. This behavior indicates that manure satisfies in part the same deficiency that lime satisfies on this medium-acid soil. The returns from the use of rock phosphate on this field are not such as to justify its unqualified recommendation. This is particularly true in the manure system. Where green manures were the source of nitrogen and organic matter, rock phosphate gave just about sufficient increase in yield to pay for its cost when used at the rate of one ton an acre once in the rotation. The Bloomington experiment field is located in part on this same type of soil. The results from this field (page 44), on which bone meal is the phosphate carrier used, show excellent returns for phosphorus and lead to the recommendation that one of the more soluble phosphates, steamed bone meal, acid phosphate, or basic slag,

be given a trial for wheat. The reader is referred to the discussion of these materials on page 34.

Brown Silt Loam On Clay occurs on the flatter areas and was formed under conditions of intermittently poor drainage. The A_1 horizon of this type is a dark brown silt loam, sometimes showing a slightly gray cast when dry. At about 10 inches in depth the color becomes somewhat lighter and at about 18 inches it becomes distinctly yellowish brown. The B horizon begins at about 21 inches and extends to about 30 inches. It is a strongly mottled, pale yellow, compact, medium-plastic clay. The C horizon is a strongly mottled, reddish brown or yellow, friable silt loam.

Management.—The Brown Silt Loam On Clay is less acid than either of the types above described. It will usually grow red clover without lime but will not grow either sweet clover or alfalfa without the application of lime. It is better supplied with organic matter and nitrogen than either of the types above described. There is no experiment field in the state located on this soil type, consequently no definite recommendations can be made for its treatment other than the use of lime as needed and the regular return of fresh organic matter.

Types of the Drift Area

In the drift area the soil which was mapped as Brown Silt Loam is now separated into two types as follows: Brown Silt Loam On Drift and Brown Silt Loam On Calcareous Drift.

Brown Silt Loam On Drift has a brown silt loam A_1 horizon to a depth of about 8 inches and frequently contains a limited number of chert and other rock fragments. The A_2 horizon is a yellowish brown silt loam containing some rock fragments and extends to a depth of about 18 or 20 inches. The B horizon is a medium-mottled, dark yellow, sandy and gravelly clay, medium compact and slightly plastic. The C horizon is a yellow, sandy, gravelly clay loam, fairly friable, and not much compacted.

In certain portions of the county a calcareous phase of the above type occurs, to which no name has yet been assigned.

Management.—There is no experiment field located on precisely this soil type. However, with allowance for a somewhat greater lime requirement in general, it is reasonable to suppose that management methods suitable for the associated type described immediately below would apply to this type also.

Brown Silt Loam On Calcareous Drift has a darker colored A_1 horizon than the preceding type and is heavier and more strongly mottled in the B horizon. It occurs on somewhat lower ground than Brown Silt Loam On Drift and is always calcareous within the three-foot section. The A_1 horizon to a depth of about 8 inches is a dark brown silt loam. The A_2 horizon to about 15 inches in depth is a brown silt loam and then changes to a yellowish brown silt loam. The B horizon is a yellow or brownish yellow clay or clay loam, compact, medium plastic, and medium mottled. The C horizon, beginning at about 25 or 30 inches, is a mottled, brownish pale yellow, fairly compact but medium friable, highly calcareous, gravelly and sandy clay loam.

Management.—The Joliet experiment field is located on soil similar to this type. The results of experiments on this field which may be found on page 46, show excellent returns from manure and from lime used with manure, fair returns from crop residues including green manure, or from residues and lime, and excellent returns from rock phosphate, particularly in the residues system. The beneficial effect on corn from the potassium treatment suggests the use in an experimental way of one of the potash salts applied at the rate of about 100 pounds an acre to the corn crop.

Black Clay Loam (920, 1120)

Black Clay Loam occupies 42.29 square miles in Woodford county, or 7.95 percent of the area of the county. It falls naturally into two groups, one in the loess area and another in the drift area; and each of these two groups, as it occurs in this county, is now recognized to include two types.

In the loess area, this soil as now mapped would be classified as Black Clay Loam On Drab Clay, and Black Clay Loam. In the drift area, this soil as now mapped would be classified as Black Clay Loam On Drab Clay, and Black Clay Loam On Plastic Calcareous Drift.

These types are more difficult to distinguish than those described under Brown Silt Loam because their occurrence is not associated with characteristic topographic expressions. For this reason, the following generalized description of the type as it is mapped will be given instead of each type as it actually exists.

The A_1 horizon is 10 to 12 inches deep, and is a dark brown to black clay loam. The A_2 horizon usually extends to a depth of about 20 inches, is drabbish black in color, and is somewhat heavier than the A_1 horizon. It usually contains small yellow spots and in the lighter portions of the type is distinctly yellow instead of drabbish black. The B horizon in the heavier portions of the type is a gray or heavily mottled, compact, and plastic clay, while in the lighter portions it is a strongly mottled yellow, compact, medium-plastic clay or clay loam.

Management.—The primary requirement to be met in the management of Black Clay Loam as it occurs in Woodford county is the regular addition of organic matter to maintain a good physical condition. Both manure and green manures may be used for this purpose, as shown by the results secured on the Minonk and Hartsburg experiment fields. The soil of the Minonk field (page 47) is similar to the Black Clay Loam of the drift area while the soil of the Hartsburg field is more nearly like that of the loess area. There has been no response to lime on the Minonk field, indicating that this material is not needed on the Black Clay Loam of the drift area. The Hartsburg field (page 51) has shown some response to lime used with manure, but used with residues adverse results have been obtained. This apparent discrepancy emphasizes the importance of applying the acidity test to each field in order to determine the need for limestone. However, it should probably not be used in excess of about 2 tons an acre. These two fields are in agreement in showing that neither rock phosphate nor potash can be used on this soil in either of the areas with any expectation of a sufficient increase in yields to pay for the cost of the materials.

Brown-Gray Silt Loam On Tight Clay (1128)

A few very small areas, aggregating only 26 acres, of Brown-Gray Silt Loam On Tight Clay occur northeast of El Paso. This type is characterized by a grayish brown A_1 horizon, an ashy gray A_2 horizon, and a highly plastic "tight clay" B horizon.

UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along the streams. They belong to the light-colored group of soils because of their low organic-matter content. The deficiency of organic matter has been caused by the long-continued growth of forest trees. After the forest invaded the prairies, two effects were produced: first, the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large organic-matter content in prairie soils; second, the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed completely or were burned by forest fires. Furthermore, the organic matter that had been produced by the prairie grasses became gradually dissipated during the occupation of the land by the trees. As a result, the organic-matter content of the upland timber soils has been reduced until it is decidedly lower than that of the adjacent prairie land. Several generations of trees were necessary to produce the present condition of the soil.

The upland timber soils of Woodford county occupy about 22 percent of the area of the county.

Yellow-Gray Silt Loam (934, 1134)

Yellow-Gray Silt Loam occupies 67.86 square miles, or 12.77 percent of the area of the county. Practically all of this type occurs within the loessial area and most of it in Woodford county, if mapped to-day, would be called Brownish Yellow-Gray Silt Loam in order to distinguish it from other types of light-colored upland soil which hitherto have all been classified as Yellow-Gray Silt Loam.

The A_1 horizon, which is about 5 inches deep in uncultivated areas and 7 or 8 inches in cultivated fields, is a brownish gray silt loam with laminated structure when not disturbed by cultivation. The A_2 horizon is a yellowish gray friable silt loam with laminated structure. The B horizon, which begins at a depth of about 14 inches, is a compact clay loam. It has a cubical structure, and the faces of the cubes are coated with a chocolate brown film, giving the entire mass a chocolate brown appearance. When this horizon is bored out with a soil auger, the sample is distinctly yellow. At a depth of about 23 inches strong mottling becomes evident and the texture appears to become finer. The C horizon begins at a depth of about 36 inches and is a friable, strongly mottled, yellow clay loam, with numerous black iron concretions appearing near the bottom of the 40-inch section.

Management.—Yellow-Gray Silt Loam, as it occurs in Woodford county, is of medium acidity. No effervescence with acid is obtained until a depth of about 60 inches is reached. Sweet clover does not grow along the roadsides except where deep ditches have been made in grading. The organic-matter and nitrogen

contents of this soil are low. The subsoil, while fairly compact, is not plastic and permits good underdrainage, while the topography allows good surface drainage on most of the type.

This soil should be treated with limestone at the rate of 2 to 3 tons an acre and then sweet clover should be seeded in the small grain. There are no experiment field results available for this type upon which to base suggestions for fertilizer treatment. It is advised, however, that a trial be made of the phosphates for wheat, after the nitrogen and organic-matter deficiencies have been taken care of, as above suggested. Yellow-Gray Silt Loam, as it occurs in Woodford county, is a productive soil when good farming methods are practiced.

Yellow Silt Loam (935, 1135)

Yellow Silt Loam occupies 49.58 square miles, or 9.31 percent of the area of the county. The character of the type varies with the changes in topography, in vegetative covering, and in the soil material from which it was formed. The rapidity of erosion is governed by the above factors, and differences in the rate of removal of surface soil determine to a large extent the character of the type. On the steeper unprotected slopes no true A_1 horizon, or surface soil, is present, and gravel may be exposed. The soil is in general grayish yellow in color and at a depth of about 20 inches becomes compact.

Management.—The management of Yellow Silt Loam is governed largely by slope. The long steep slopes should be kept in timber or in permanent pasture, while the slopes less subject to erosion may be put in grain at intervals. Much of this type as found in Woodford county will grow alfalfa without the use of lime. Advantage should be more generally taken of this fact, as it offers the opportunity to grow a profitable crop and at the same time control erosion. For more specific information on the control of erosion, the reader is referred to the discussion of the Vienna experiment field, page 52, and also to Bulletin 207 and Circular 290 of this Station.

Dune Sand (1181)

Dune Sand occurs in small disconnected areas on the upland near Spring Bay. The total area of the type in Woodford county is slightly less than one square mile. The time which has elapsed since the soil material of this type was deposited has been too short to allow the formation of horizons. The surface to a depth of about 7 inches is a grayish yellow, medium-coarse sand, and the only observable difference which appears below this depth is a change in color to brownish yellow.

Management.—Dune Sand, as it occurs in Woodford county, is less coarse than is usual for the type and is fairly well adapted to the general farm crops. It is medium acid and requires about 2 tons of limestone an acre to grow sweet clover or alfalfa. It is well suited to the production of melons or other crops liking a sandy soil. It should grow good potatoes if well fertilized with a mixture high in soluble phosphate and potash. For an account of experiments on sand, see the discussion of the Oquawka experiment field, page 54.

SWAMP AND BOTTOM-LAND SOILS

In the group designated as swamp and bottom-land soils are included the bottom lands or flood plains along streams, the swamps, the poorly drained lowlands, and also all peats and mucks, whether on upland or terrace. Much of the soil is of alluvial formation, and the land is largely subject to overflow.

Deep Peat (1401)

A total of only 384 acres of Deep Peat is found in Woodford county and most of the areas are untilled because the drainage has not been taken care of. When drained, this type is well adapted to trucking and also grows good corn when fertilized with potash salts. Experiments in improving the fertility of Peat were carried on at the Manito field, described on page 56.

Brown Silt Loam (1426)

Brown Silt Loam, Bottom, occurs in the Illinois bottom north of Partridge creek and adjacent to the swamp found in this corner of Woodford county, from which it is protected by a dike. The A_1 horizon is dark brown silt loam to a depth of about 8 or 9 inches. Below this depth, the color becomes slightly drabbish brown and gradually changes to a drabbish gray with rust-colored iron spots. The texture becomes finer with increasing depth. There are, however, no well-developed horizons because of the youth of this soil.

Management.—Brown Silt Loam, Bottom, is an excellent soil and when properly drained and protected from flooding is very desirable farm land. No treatment is advised for this type in Woodford county other than good farming, the return of fresh organic matter at regular intervals, and the use of lime if experience shows this material to be needed.

Mixed Loam (1454)

Mixed Loam occurs in the Illinois bottom and also in the smaller bottoms which are tributary to Illinois river. A total of 31.76 square miles of the type is found in Woodford county.

This type as it is mapped varies greatly in nearly all the characters which are taken into consideration in separating soils into types. It is in reality not a soil type, but is made up of a number of types which occur in areas too small to be shown on the map. The color of this soil varies from black to light brown and the texture from clay loam to sandy loam.

Management.—Mixed Loam, as it occurs in Woodford county, is a productive soil. Provision for the removal of excess water, both the normal rainfall and flood water, is the chief requirement in its management.

Brown Sandy Loam (1460)

Brown Sandy Loam, Bottom, occurs in two small areas in the Illinois bottom north of Panther creek and has a total area of only 70 acres. It differs from the surrounding silt loam in texture and is slightly higher in elevation. The management requirements of this type are not essentially different from those of Brown Silt Loam, Bottom.

TERRACE SOILS

Terrace soils are formed on terraces or old fills in valleys. The terraces owe their formation generally to the deposition of material from over-loaded streams which became greatly enlarged and which flooded the valleys during the melting of the glaciers. Sometimes these valleys were filled almost to the height of the upland. Later the streams cut down thru the fills and developed new bottom lands, or flood plains, at lower levels, leaving part of the old fills as terraces. The lowest and most recently formed bottom land is called first bottom. The higher land no longer flooded (or very rarely, at most) is generally designated as second bottom, or terrace. Finer material later deposited on the sand and gravel of the fill constitutes the mineral portion of the soil.

Brown Silt Loam Over Gravel (1527)

Brown Silt Loam Over Gravel occurs, for the most part, in a belt about half a mile wide and four miles long south of Spring Bay. It occupies a total area of 2.22 square miles. The A_1 horizon is brown silt loam which changes gradually to a yellowish brown silt loam, becoming fairly compact at 25 to 30 inches in depth.

This type varies somewhat in agricultural value depending on distance from the bluff. As the bluff is approached, the soil becomes better because of the calcareous outwash material which it receives. Along the edge of the type towards the river, small areas or narrow belts of relatively poor land occur which are drouthy because of the open, sandy subsoil.

Management.—Brown Silt Loam Over Gravel requires in general the same management as Brown Silt Loam, Upland (see page 15), and except for the poorer portions of the type mentioned above should respond satisfactorily.

Brown Silt Loam On Gravel (1526.4)

A total of only 96 acres of Brown Silt Loam On Gravel is mapped in Woodford county. The surface soil of this type is the same as that of the preceding type, Brown Silt Loam Over Gravel. The difference between the two types lies in the fact that the gravel substratum is nearer the surface in the Brown Silt Loam On Gravel, making this type more generally drouthy.

Management.—Brown Silt Loam On Gravel is not a good soil for general farming because of its drouthy nature. Nothing can be done to remedy materially this condition. In addition to the use of good farming methods, early-maturing crops should be chosen in so far as possible.

Brown Sandy Loam Over Gravel (1566)

Only a small amount of Brown Sandy Loam Over Gravel occurs in Woodford county, a total of 128 acres. It is found south of Spring Bay in association with River Sand (1580) and Brown Silt Loam Over Gravel (1527), and was formed by the mixture of sufficient sand from the adjacent dunes with the low-lying silt loam to make a sandy loam. The type varies in texture and in the depth of the sand-silt mixture. The underlying gravel stratum is sufficiently deep not to interfere with moisture movement.

Management.—Brown Sandy Loam Over Gravel is an excellent vegetable or trucking soil and grows good general farm crops. It is medium acid and requires 2 to 3 tons of limestone an acre for alfalfa or sweet clover. The decay of organic matter is rapid in this soil and adequate provision should be made for returning fresh supplies of this essential material to it at regular intervals.

Brown Sandy Loam On Gravel (1560.4)

Brown Sandy Loam On Gravel occurs south of Spring Bay as small areas in association with the sand, sandy loam, and silt loam types of this region. It is similar in appearance to the preceding type, Brown Sandy Loam Over Gravel, and is distinguishable from it only by examining the subsoil. It is a drouthy type because of the nearness of the gravel substratum to the surface. A total of 1,146 acres of this type is found in Woodford county.

Management.—Brown Sandy Loam On Gravel is medium acid and needs 2 or 3 tons of limestone an acre. It is not a good soil for the general farm crops because of its drouthy nature. No method is known of adequately overcoming this defect since this condition is due to the character of the subsoil, which cannot be changed. Some improvement can be made by increasing the organic-matter content of the surface soil, thus slightly increasing its water-holding capacity. The best way to use soil of this drouthy nature is to grow early maturing crops on it, thus largely avoiding the unfavorable effects of dry midsummer weather.

Yellow-Gray Silt Loam Over Gravel (1536)

The largest areas of Yellow-Gray Silt Loam Over Gravel occur along Mackinaw river. A total of 2.87 square miles of the type is found in Woodford county. It is similar to Yellow-Gray Silt Loam, Upland, in all respects except method of formation, and the reader is referred to the discussion of that type (page 18).

Yellow-Gray Sandy Loam Over Gravel (1567)

Yellow-Gray Sandy Loam Over Gravel occurs in narrow belts adjacent to streams where the overflow conditions have been such that sand was carried out by the stream and deposited. Less than half a square mile of this type occurs in Woodford county. It has a yellowish gray sandy loam surface which grades into yellowish sandy loam with a medium degree of compaction. Some gray mottling appears at about 20 inches in depth.

Management.—This type should be managed in the same way as the preceding type, Yellow-Gray Silt Loam Over Gravel. It is a less productive type, because of its high sand content, but will respond satisfactorily to good farming.

River Sand (1580)

A total of 1,088 acres of River Sand occurs south of Spring Bay. This soil material was deposited both by wind and water and has a dune-like topography.

The surface is a brownish yellow sand which passes into yellow sand at a depth of 7 or 8 inches. No B or C horizons have been developed in this soil because of its youth.

Management.—River sand is naturally a poor soil for general farming, but with the use of about 3 tons of limestone an acre will grow good sweet clover and alfalfa, and following a thrifty growth of these legumes, fair crops of corn, wheat, and rye are produced. It is a good melon soil. See page 54 for an account of experiments on the Oquawka field located on Dune Sand, which is very similar to this type as it occurs in Woodford county.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items such as native vegetation (whether timber or prairie), topography, and geological origin and formation may assist in the differentiation of types, altho they are not fundamental to it.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a matured soil, three horizons designated as A, B, and C are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the A horizon.

C designates the layer lying below the B horizon and in which the material has been less affected by the weathering processes.

Frequently differences within these strata or zones are discernible, in which case they are subdivided and described under such designations as A_1, and A_2, B_1 and B_2, etc.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in differentiating soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation

1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* formed by material derived from the Illinoisan or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction.

Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5.
[2]Young second-year growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely or entirely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated

with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should

be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grading insures

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4, have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of mod-

erate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogeneous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, acid phosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate, and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the

oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average livestock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible

to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal protèins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical

condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the better adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year—Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year—Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year—Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year—Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year—Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year—Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year—Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year—Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to those Occurring in Woodford County)

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system. Some modifications have been made in recent years.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated (aP = acid phosphate, bP = bonemeal, rP = rock phosphate, sP = slag phosphate)
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
Le = Legume used as green manure
Cv = Cover crop
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed
| = Heavy vertical rule, indicating the beginning of complete treatment
|| = Double vertical rule, indicating a radical change in the cropping system

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

THE MT. MORRIS FIELD

The Mt. Morris experiment field was established in 1910 at Mt. Morris in Ogle county. The soil represents fairly well the type Light Brown Silt Loam, altho the plots are not altogether uniform in this respect. The plots considered

TABLE 7.—MT. MORRIS FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields, 1913-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *13 crops*	Oats *13 crops*	Wheat *11 crops*	Clover[1] *10 crops*	Soybeans *2 crops*
1	0	45.2	59.1	22.8	(2.10)	(1.56)
2	M	59.5	67.8	27.7	(2.62)	(1.70)
3	ML	64.2	70.2	33.7	(3.00)	(1.80)
4	MLrP	64.5	71.4	35.5	(2.92)	(1.92)
5	0	44.9	56.5	23.0	(1.74)	13.5
6	R	51.3	60.9	25.3	(1.90)	16.0
7	RL	62.5	69.3	32.1	(2.27)	18.9
8	RLrP	65.7	70.2	35.7	(2.22)	20.7
9	RLrPK	67.4	70.5	35.5	(2.20)	20.0
10	0	44.0	53.6	24.7	(1.95)	(1.68)
	M over 0	14.3	8.7	4.9	(.52)	(.14)
	R over 0	6.4	4.4	2.3	(.16)	2.5
	ML over M	4.7	2.4	6.0	(.38)	(.10)
	RL over R	11.2	8.4	6.8	(.37)	2.9
	MLrP over ML	.3	1.2	1.8	−(.08)	(.12)
	RLrP over RL	3.2	.9	3.6	−(.05)	1.8
	RLrPK over RLrP	1.7	.3	−.2	−(.02)	− .7

[1]Some clover seed evaluated as hay.

here comprize four series under a rotation of corn, oats, clover, and wheat, with soil treatments as indicated in the accompanying table. The application of straw to the residues plots has been discontinued in these later years. In 1922 the application of limestone and in 1923 the application of rock phosphate were indefinitely suspended in order to observe the residual effect of these materials.

A summary of the results of the work is given in Table 7, in the form of the average annual crop yields for the years since the complete soil treatments have been in effect.

The results bring out clearly the need of this soil for organic matter. Without limestone, manure has been far more effective than residues. Limestone, however, has been applied with beneficial effect either with manure or with residues, but the response has been decidedly the greater in the residues system.

Rock phosphate has produced no significant effect when applied with manure and limestone, and the increases in yield obtained from rock phosphate in the residues system have not been sufficient to cover the cost of material as it has been used. Potassium as used in these experiments has produced no significant effect on crop yields.

THE KEWANEE FIELD

A field on soil similar to much of the Brown Silt Loam as it occurs in Woodford county is the Kewanee field, located in Henry county about three miles southwest of Kewanee. This field has been under way since 1915. The crops grown are wheat, corn, oats, and clover. The arrangement of plots and the treatments applied are indicated in Table 8.

TABLE 8.—KEWANEE FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1917-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *9 crops*	Oats *9 crops*	Wheat *7 crops*	Clover *8 crops*
1	0	54.4	58.4	29.9	(1.85)
2	M	64.3	69.0	31.5	(2.36)
3	ML	68.2	71.8	34.0	(2.32)
4	MLrP	69.1	70.1	38.3	(2.45)
5	0	55.5	59.8	30.5	(1.74)
6	R	57.5	58.6	31.5	(1.71)
7	RL	66.0	63.0	32.5	(1.93)
8	RLrP	70.3	66.9	37.8	(2.08)
9	RLrPK	72.4	68.2	37.8	(2.12)
10	0	51.2	54.6	30.1	(1.73)
	M over 0	9.9	10.6	1.6	(.51)
	R over 0	2.0	−1.2	1.0	−(.03)
	ML over M	3.9	2.8	2.5	−(.04)
	RL over R	8.5	4.4	1.0	(.22)
	MLrP over ML	.9	−1.7	4.3	(.13)
	RLrP over RL	4.3	3.9	5.3	(.15)
	RLrPK over RLrP	2.1	1.3	0.0	(.04)

Summarizing the data as shown in Table 8 the following observations may be made.

1. The response to treatment with stable manure stands out clearly in the increase in production.

2. Residues without limestone have not produced a very decided effect on crop yields.

3. The effect of limestone appears to have been beneficial used either with manure or with residues.

4. Phosphorus, as usual, has been more effective applied with residues than with manure. In the residues system the rock phosphate has just about returned the cost of application, but in the manure system the increases in crop yield have fallen far short of covering the cost.

5. Potassium has produced no effect upon the yields of these crops that can be considered significant.

THE BLOOMINGTON FIELD

The experiments on the Bloomington field are of interest in connection with the management of much of the upland prairie soil as it occurs in Woodford county. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. A radical change in the plan of the experiments was made in 1923, and for this reason the present discussion will involve results only up to that year. Altho a fairly long period of years is covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn,

corn, oats, clover, and wheat; and, since 1905, they have been grown in the sequence named.

On account of irregularities in the land results from Plots 1 and 10 are not considered altogether reliable. They, therefore, are not included in the figures presented. Since these are the only unlimed plots, no conclusion can be drawn regarding the action of limestone on this field.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. The phosphorus on this field was applied in the form of steamed bone meal and at the rate of 200 pounds an acre a year.

Table 9 presents a summary of the work by annual average crop yields. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they were applied. As might be expected, the residues treatment, supplying organic matter and nitrogen, shows a beneficial effect. It is of interest to note that the effect of the residues is greater on the phosphorus plots than on those not receiving phosphorus.

The outstanding feature of the results on the Bloomington field is the effect of phosphorus applied in the form of steamed bone meal. In every crop on every plot where bone meal was applied there has been a remarkable response to the treatment as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with

TABLE 9.—BLOOMINGTON FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1902-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*	Clover[1] *3 crops*
2	L	41.5	44.7	24.1	(.80)
3	LR	47.5	46.2	27.9	(.88)
4	LbP	55.8	54.3	45.7	(2.54)
5	LK	46.2	43.5	25.5	(.93)
6	LRbP	60.6	66.0	49.7	(1.19)
7	LRK	48.6	46.8	27.5	(.82)
8	LbPK	60.9	57.2	44.5	(2.44)
9	LRbPK	64.2	63.1	50.4	(.81)
	Increases: Bushels per acre				
	For Residues				
	LR over L	6.0	1.5	3.8	(.08)
	LRbP " LbP	4.8	11.7	4.0	−(1.35)
	LRK " LK	2.4	3.3	2.0	−(.11)
	LRbPK " LbPK	3.3	5.9	5.9	−(1.63)
	For Phosphorus				
	LbP over L	14.3	9.6	21.6	(1.74)
	LRbP " LR	13.1	19.8	21.8	(.31)
	LbPK " LK	14.7	13.7	19.0	(1.51)
	LRbPK " LRK	15.6	16.3	22.9	−(.01)
	For Potassium				
	LK over L	4.7	−1.2	1.4	(.13)
	LRK " LR	1.1	.6	−.4	−(.06)
	LbPK " LbP	5.1	2.9	−1.2	−(.10)
	LRbPK " LRbP	3.6	−2.9	.7	−(.38)

[1]Two crops of clover seed on Plots 3, 6, 7, 9, and 10 evaluated as hay.

either residues or potassium the effect is accentuated. For example, if we compare Plot 3 with Plot 6 (limestone and residues with limestone, residues, and phosphorus) we find that the phosphorus treatment has produced an average increase of about 13 bushels of corn to the acre, while the yield of oats has been increased by about 20 bushels, wheat by about 22 bushels, and clover hay by about ⅓ ton. Similar increases appear in comparing Plot 5 with Plot 8, where potassium instead of residues is present.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is distinctly a limiting factor in production, and the application of this element in the form of steamed bone meal is attended by a high financial profit. It is of extreme interest to know whether a similar response would follow the use of other phosphorus carriers, such as rock phosphate and acid phosphate, and experiments are now under way designed to answer this question.

Quite different are the results from the use of potassium on this field. The potassium was applied mainly in the form of potassium sulfate, but in 1917 when this material became unavailable thru war conditions, potassium carbonate was substituted. There has been a moderate increase in the corn yield where potassium was used and particularly where residues were absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

THE JOLIET FIELD

The Joliet experiment field is located in Will county about three miles northwest of Joliet. Aside from a few spots of Black Clay Loam On Drab Clay the soil is made up of the types Brown Silt Loam On Calcareous Drift and Brown Silt Loam On Plastic Calcareous Drift. The main plot system, the one which will be considered here, is made up of six series of plots under the soil treatments indicated in Table 10. The original crop rotation practiced included corn, oats, clover, wheat, and soybeans, with alfalfa on a sixth series remaining six years. In 1921 the rotation was changed to corn, corn, oats, clover, and wheat, with a seeding of sweet clover on the residues plots, and alfalfa on the sixth series for six years. Since 1921 all clover has been removed as hay. In 1921 the return of the oats straw was discontinued, as was also the wheat straw the following year. The application of limestone was likewise discontinued in 1922, to be resumed when need for more lime becomes apparent.

The results secured from these experiments are summarized in Table 10 to show the average annual yields of the several crops including the years since the complete soil treatments have been in effect.

In looking over these results one may observe first a beneficial effect of manure on all crops, but most pronounced on the corn. This suggests the importance of carefully conserving and regularly applying all available stable manure. Residues, used alone, have produced some increase in the corn, but have had little effect on the yield of other crops.

Where limestone is applied usually there has been some increase in yield. Limestone has been especially beneficial to alfalfa.

TABLE 10.—JOLIET FIELD, SERIES 100-600: SUMMARY OF CROP YIELDS
Average Annual Yields 1915-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *16 crops*	Oats *11 crops*	Wheat *8 crops*	Clover[1] *6 crops*	Soybeans *4 crops*	Alfalfa *4 crops*
1	0	31.3	56.4	21.7	(.98)	(1.26)	(1.27)
2	M	40.2	61.8	26.2	(1.31)	(1.39)	(1.69)
3	ML	44.8	63.2	30.4	(1.37)	(1.48)	(2.42)
4	MLrP	48.2	67.4	37.9	(1.66)	(1.59)	(3.21)
5	0	32.3	57.1	21.7	(.95)	12.1	(1.19)
6	R	37.3	58.0	23.3	(.81)	12.1	(1.14)
7	RL	41.1	60.4	25.2	(1.01)	14.1	(1.81)
8	RLrP	46.4	66.2	36.4	(1.55)	16.2	(3.52)
9	RLrPK	50.8	67.0	39.9	(1.67)	16.8	(3.46)
10	0	33.6	57.3	23.0	(1.12)	(1.14)	(1.35)
	M over 0	8.9	5.4	4.5	(.33)	(.13)	(.42)
	R over 0	5.0	.9	1.6	−(.14)	0.0	−(.05)
	ML over M	4.6	1.4	4.2	(.06)	(.09)	(.73)
	RL over R	3.8	2.4	1.9	(.20)	2.0	(.67)
	MLrP over ML	3.4	4.2	7.5	(.29)	(.11)	(.79)
	RLrP over RL	5.3	5.8	11.2	(.54)	2.1	(1.71)
	RLrPK over RLrP	4.4	.8	3.5	(.12)	.6	−(.06)

[1]One crop of seed on Plots 6, 7, 8, and 9 evaluated as hay.

Very marked increases have followed the application of rock phosphate, the use of this material having proved exceedingly profitable on this field. Profitable response to potassium in the fertilizer combination here used has been secured only in the corn and wheat, so that considering the rotation as a whole, the value of crop increase has not been sufficient to cover the cost of material. It is possible that by reducing the expense thru the use of smaller quantities of material, the potassium fertilization could be made profitable.

THE MINONK FIELD

A University soil experiment field is located in Woodford county about a mile west of Minonk. This field was established in 1910. It comprizes 15 acres of dark-colored prairie soil of loessial and drift origin. The experimental plots lie mainly on Black Clay Loam On Drab Clay, altho a detailed examination reveals the presence of three other soil types distinguishable on account of certain profile characteristics. These are Brown Silt Loam, Brown Silt Loam On Calcareous Drift, and Brown Silt Loam On Calcareous Clay. The distribution of these soil types, as well as the arrangement of plots, is charted on the accompanying diagram (Fig. 2). The diagram also indicates by contour lines the topography of the land.

The field is laid out into four series of 10 plots each. The plots are one-fifth acre in size except in Series 100, where they are one-tenth acre. A crop rotation of corn, oats, clover, and wheat was practiced until 1923, when it was changed to corn, corn, oats, and wheat, with a seeding of hubam clover in the oats on all plots and biennial sweet clover in the wheat on the residues plots. In 1921 the practice of returning the oats straw on the residues plots was discontinued, and

TABLE 11.—MINONK FIELD: ANNUAL CROP YIELDS

Bushels or (tons) per acre

Plot No.	Soil treatment applied	1910 Barley[1]	1911 Corn[2]	1912 Oats[4]	1913 Clover[4]	1914 Wheat[5]	1915 Corn	1916 Oats	1917 Soy-beans	1918 Wheat	1919 Corn	1920 Oats	1921 Soy-beans	1922 Wheat	1923 Corn	1924 Oats	1924 Stubble clover	1925 Wheat	1926 Corn
101	0.....	38.1	72.8	42.8	(3.94)	53.2	51.8	63.1	(1.43)	40.1	55.8	71.2	34.8	34.3	38.4	58.8	(.92)	29.2	55.4
102	M.....	29.4	66.8	43.4	(4.04)	51.3	56.4	55.3	(1.70)	45.0	65.6	73.4	35.8	35.8	49.8	65.3	(1.21)	28.3	72.0
103	ML.....	29.5	63.1	39.7	(3.86)	55.8	61.4	55.6	(1.94)	38.7	67.2	67.5	37.2	31.8	50.2	61.6	(.85)	29.8	67.4
104	MLrP....	33.7	61.0	39.1	(3.61)	49.0	57.0	50.9	(2.06)	34.2	66.8	63.4	36.5	30.2	47.6	54.1	(.89)	28.3	69.0
105	0.....	33.0	58.6	41.3	.67	53.0	50.0	52.2	20.0	38.3	58.6	65.0	34.5	30.0	37.4	48.1	(.95)	29.2	53.0
106	R.....	36.9	72.3	51.3	.83	47.0	52.2	55.9	19.2	34.8	54.2	96.6	33.8	32.5	55.2	85.9	(.80)	37.7	71.6
107	RL.....	39.9	71.2	42.5	.67	35.2	43.8	58.1	18.0	28.2	60.2	92.5	32.3	31.0	52.0	85.3	(.83)	30.2	68.2
108	RLrP.....	44.0	72.4	37.5	.67	33.8	40.2	60.6	17.8	32.0	59.2	94.4	31.5	33.3	51.4	84.7	(1.06)	30.0	78.0
109	RLrPK...	39.5	73.8	31.9	.50	29.8	43.8	60.6	16.0	31.0	55.6	89.4	25.8	30.3	51.8	83.8	(1.17)	25.5	69.6
110	0.....	42.4	68.8	34.4	(1.63)	27.3	43.6	56.9	(1.23)	22.7	51.4	71.2	25.5	21.2	30.2	54.1	(.57)	16.2	49.6

		Soy-beans[1]	Wheat[3]	Corn	Oats	Soy-beans	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Corn	Corn	Oats	Wheat	Stubble Clover
201	0.....	13.3	25.9	65.4	39.7	(1.10)	52.2	37.5	76.1	(4.35)	33.3	56.4	31.6	(3.36)	48.9	49.3	65.3	36.6	....
202	M.....	14.7	25.7	70.6	38.0	(1.22)	52.6	35.7	67.0	(4.30)	33.7	67.0	33.3	(4.03)	56.5	46.9	68.6	38.2	....
203	ML.....	15.0	28.5	69.4	41.6	(1.23)	53.6	35.1	73.8	(4.57)	32.8	68.1	32.3	(3.59)	59.2	46.6	66.1	37.0	....
204	MLrP.....	14.7	25.8	74.3	41.6	(.98)	61.1	31.6	65.8	(4.59)	32.4	61.7	32.3	(3.42)	54.9	46.0	65.6	38.8	....
205	0.....	13.3	26.0	63.9	39.1	8.7	51.0	26.4	63.6	.75	31.2	54.8	31.7	(2.94)	46.5	47.8	66.6	35.6	....
206	R.....	12.5	26.8	65.0	35.0	10.8	51.2	37.1	78.9	1.08	32.7	62.0	30.6	(3.16)	54.2	56.1	71.6	37.6	(1.22)
207	RL.....	13.5	22.7	69.7	36.2	8.5	49.9	34.9	75.0	.92	33.0	61.6	26.4	(2.75)	48.3	54.9	68.6	31.1	(1.20)
208	RLrP.....	11.2	22.2	68.4	40.2	8.8	47.6	35.6	79.7	.42	36.2	65.8	29.4	(3.18)	49.1	56.4	66.4	37.1	(1.36)
209	RLrPK...	11.8	23.8	69.8	44.4	7.7	48.1	34.6	78.9	.67	34.2	64.2	30.3	(3.38)	49.2	58.1	70.3	34.7	(1.59)
210	0.....	12.7	20.0	66.3	44.1	8.5	44.5	22.8	63.8	(3.75)	32.4	44.7	33.9	(2.35)	35.0	41.1	57.3	26.8	....

[1]No treatment. [2]Residues only. [3]No manure or limestone. [4]Residues and limestone only. [5]No manure.

TABLE 11.—*Concluded*

Bushels or (tons) per acre

Plot No.	Soil treatment applied	1910 Oats[1]	1911 Clover[2]	1912 Wheat[4]	1913 Corn	1914 Oats	1915 Soy-beans	1916 Wheat	1917 Corn	1918 Oats	1919 Clover	1920 Wheat	1921 Corn	1922 Oats	1923 Wheat	1924 Corn	1925 Corn	1926 Oats	1926 Stubble Clover
301	0.....	67.2	(2.75)	11.1	54.1	40.6	(1.72)	30.7	54.7	60.3	(2.41)	42.8	56.4	74.8	31.3	45.8	60 1	52.8	(.53)
302	M.....	66.9	(2.65)	11.3	63.9	42.0	(1.70)	37.7	63.8	65.3	(2.72)	47.5	75.8	81.4	37.9	68.8	70.5	66.6	(.67)
303	ML.....	65.5	(2.54)	15.6	60.6	43.3	(1.78)	35.1	67.5	65.3	(2.48)	42.4	83.3	80.9	28.8	60.5	73.5	61.4	(.82)
304	MLrP.....	62.8	(2.65)	17.9	65.2	44.8	(1.70)	38.0	69.3	64.7	(2.67)	46.0	85.4	76.9	37.3	56.2	77.3	63.3	(.85)
305	0.....	58.3	(2.82)	15.3	57.9	45.0	19.7	34.5	46.4	58.6	(1.75) .59	42.8	70.4	66.1	30.8	40.6	49.1	55.5	(.77)
306	R.....	58.3	....[3]..	17.8	64.0	44.5	18.6	38.3	60.6	60.9	(1.54) .54	40.2	77.6	69.7	36.8	53.3	63.7	48.4	(1.02)
307	RL.....	56.7	....[3]..	15.8	62.0	45.8	18.3	35.5	70.0	60.9	(1.38) .56	35.8	81.7	67.0	30.4	60.5	61.4	47.8	(.97)
308	RLrP.....	56.9	....[3]..	18.0	58.7	42.5	20.7	34.4	68.7	63.1	(1.21) .39	39.0	77.5	70.5	29.9	67.2	66.2	52.5	(1.06)
309	RLrPK...	61.9	....[3]..	13.3	59.2	38.8	19.2	31.8	69.9	64.5	(1.13) .30	35.6	80.3	69.2	30.9	56.2	61.6	53.4	(1.24)
310	0.....	64.2	(2.05)	6.7	44.5	29.2	(1.63)	28.2	52.9	59.5	(1.81)	33.5	61.2	63.3	23.6	38.4	31.8	46 3	(.59)
		Corn[1]	Oats[2]	Soy-beans[5]	Wheat[4]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats	Wheat	Corn	Corn	
401	0.....	52.0	52.5	(1.27)	33.8	19.9	89.4	(2.07)	9.9	60.9	52.0	(.70)	29.2	52.0	49.7	26.8	42.2	45.3	
402	M.....	48.9	52.5	(1.54)	31.8	22.6	93.0	(2.06)	14.0	70.5	49.2	(.92)	28.5	70.3	57.7	33.9	68.7	63.5	
403	ML.....	50.9	55.3	(1.10)	27.9	18.7	93.4	(1.82)	11.2	75.6	49.5	(1.24)	29.3	71.3	57.2	39.6	68.8	58.1	
404	MLrP.....	51.8	49.4	(1.24)	33.5	24.7	103.1	(2.32)	17.1	78.5	49.5	(1.66)	30.1	73.0	64.2	39.9	74.4	59.1	
405	0.....	52.4	55.6	10.7	33.7	24.2	93.4	.25	17.9	61.4	48.6	(.54)	28.2	54.8	50.5	33.8	43.9	44.8	
406	R.....	49.6	56.4	10.6	39.2	33.8	88.1	.08	23.9	71.4	48.8	(1.11)	29.4	74.1	55.2	35.0	58.9	55.7	
407	RL.....	45.4	54.8	11.5	38.7	38.6	100.0	0.00	21.2	77.3	48.0	(1.93)	26.4	83.2	58.9	38.3	74.4	64.2	
408	RLrP.....	45.0	55.5	11.5	41.2	35.8	101.9	.08	22.8	78.3	49.4	(2.09)	28.8	87.3	64.5	41.1	71.0	69.0	
409	RLrPK...	51.6	53.3	11.4	44.0	35.9	105.5	.08	21.5	70.0	49.2	(1.89)	32.7	78.7	65.0	41.2	70.9	57.5	
410	0.....	45.4	53.4	13.0	36.7	27.5	106.0	(2.30)	12.1	58.0	45.2	(1.28)	30.7	55.2	61.3	32.0	43.2	52.6	

[1]No treatment. [2]Residues only. [3]Growth plowed down. [4]No manure. [5]Residues and limestone only.

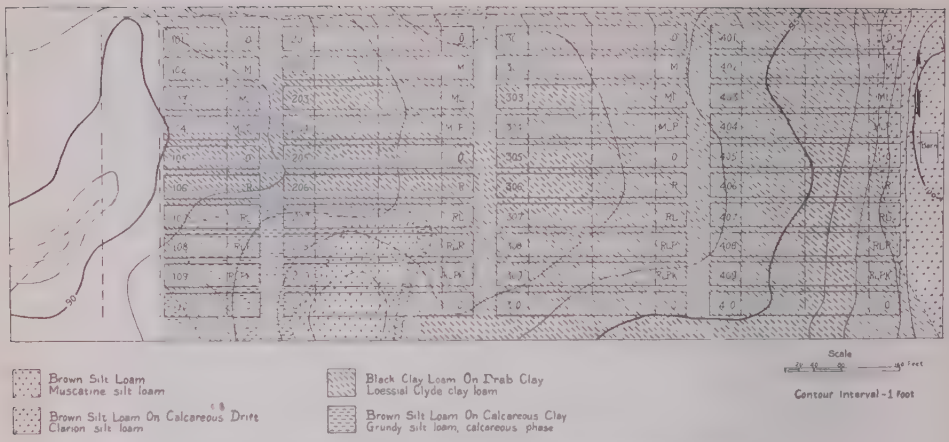

Brown Silt Loam
Muscatine silt loam
Brown Silt Loam On Calcareous Drift
Clarion silt loam
Black Clay Loam On Drab Clay
Loessial Clyde clay loam
Brown Silt Loam On Calcareous Clay
Grundy silt loam, calcareous phase
Scale
Contour Interval -1 foot

FIG. 2.—DIAGRAM OF THE MINONK EXPERIMENT FIELD

This diagram shows the arrangement of plots, the soil treatments applied, the location of the different soil types, and by means of contour lines, the natural drainage of this field.

in 1922 the return of the wheat straw was likewise discontinued. Up to this time limestone, varying in total quantity from 7½ to 9 tons an acre on the different series, had been applied. These applications were then suspended until such time as the need for more lime becomes apparent. The applications of phosphate were likewise indefinitely suspended in 1923 after evening up the total phosphate applied to 4 tons an acre on all the phosphate plots.

TABLE 12.—MINONK FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1912-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *19 crops*	Oats *14 crops*	Wheat *12 crops*	Clover[1] *7 crops*	Soybeans *4 crops*
1	0	50.0	59.0	33.0	2.05	19.3
2	M	61.0	61.2	36.1	2.27	20.5
3	ML	61.2	60.7	34.2	2.20	21.7
4	MLrP	61.7	60.0	36.1	2.34	21.0
5	0	49.0	56.0	33.6	1.22	20.7
6	R	59.0	62.2	35.8	1.33	20.6
7	RL	61.4	62.2	32.6	1.33	19.3
8	RLrP	62.3	64.3	34.4	1.36	19.7
9	RLrPK	59.8	64.5	33.1	1.41	17.2
10	0	45.3	56.6	27.0	1.81	15.3
	M over 0	11.0	2.2	3.1	.22	1.2
	R over 0	10.0	6.2	2.2	.11	− .1
	ML over M	.2	− .5	−1.9	− .07	1.2
	RL over R	2.4	0.0	−3.2	0.00	−1.3
	MLrP over ML	.5	− .7	1.9	.14	− .7
	RLrP over RL	.9	2.1	1.8	.03	.4
	RLrPK over RLrP	−2.5	.2	−1.3	.05	−2.5

[1]Including the 1919 seed crop from Plots 105, 106, 107, 108 and 109 evaluated as hay and also two crops of stubble clover.

A record of the yield of all crops produced in these experiments is given in Table 11, but for convenience the results obtained since the complete soil treatments have been in effect are summarized in Table 12.

In looking over these results, one observes first the naturally high productiveness of this land. There is more or less response to farm manure; in the corn the yield is markedly increased by its use. Residues alone have likewise increased the yields of the grain crops. Limestone seems to have had no material effect on crop yields. Evidently this soil does not need lime. Rock Phosphate has proved ineffective when applied with manure and limestone, and when used with residues and limestone the increases in yield are too small to offset the cost of material. Potassium as used in these experiments has likewise been ineffective.

These results therefore indicate the advisability of furnishing plenty of organic matter, either thru stable manure or thru crop residues, including leguminous green manure, as the best practical means of improving the productiveness of this naturally fertile soil.

THE HARTSBURG FIELD

The results of experiments on the Hartsburg field are introduced as representing the soil type Black Clay Loam On Drab Clay. This field is located in Logan county just east of Hartsburg. The work began in 1911. The field was laid off into five series of 10 plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series. The soil treatments

TABLE 13.—HARTSBURG FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1913-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn[1] *17 crops*	Oats *13 crops*	Wheat *11 crops*	Clover[2] *6 crops*	Soybeans *2 crops*	Alfalfa[3] *10 crops*
1	0	46.7	47.6	25.6	(2.19)	(1.29)	(3.47)
2	M	56.6	53.0	30.1	(2.59)	(1.65)	(3.67)
3	ML	62.9	58.7	35.6	(2.67)	(1.82)	(3.91)
4	MLrP	61.5	58.6	38.1	(2.80)	(1.93)	(4.19)
5	0	52.6	46.2	30.9	(1.48)	25.8	(3.33)
6	R	62.6	54.9	34.1	(1.91)	26.8	(3.78)
7	RL	66.9	53.0	31.3	(1.82)	28.5	(3.45)
8	RLrP	65.8	57.4	35.3	(1.97)	26.2	(4.04)
9	RLrPK	65.2	56.7	34.7	(1.89)	26.5	(4.16)
10	0	52.7	48.3	31.6	(2.35)	(1.69)	(3.20)
	M over 0	9.9	5.4	4.5	(.40)	(.36)	(.20)
	R over 0	10.0	8.7	3.2	(.43)	1.0	(.45)
	ML over M	6.3	5.7	5.5	(.08)	(.17)	(.24)
	RL over R	4.3	−1.9	−2.8	−(.09)	1.7	−(.33)
	MLrP over ML	−1.4	− .1	2.5	(.13)	(.11)	(.28)
	RLrP over RL	−1.1	4.4	4.0	(.15)	−2.3	(.59)
	RLrPK over RLrP	− .6	− .7	− .6	−(.08)	.3	(.12)

[1]One corn crop without residues.
[2]One crop stubble clover included; some seed evaluated as hay on Plots 5, 6, 7, 8, and 9.
[3]No residues for the first 6 crops.

are as indicated in Table 13. The table summarizes, by crops, the yields of grain for the period during which the plots have been under full treatment.

The outstanding feature of these results is the large increase in yields produced by residues, which even exceeds the increase brought about by the use of stable manure.

The behavior of limestone on this field is rather peculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure, limestone shows some increase in all crops, while with residues, the effect on several of the crops appears negative.

Altho rock phosphate has given some increases in wheat yield in both manure and residues systems, the results with other crops have been such as to render the use of this material unprofitable on this field.

The addition of potassium appears to have produced no significant effect upon the yields of any of the crops.

It may be mentioned that new experiments have been recently started on these plots which are designed to answer some of the questions brought out by the foregoing results. For example, the effect of applying phosphorus in other carriers and in different combinations, as well as testing the residual effect of phosphate already applied, is being tried.

THE VIENNA FIELD

Inasmuch as about 50 square miles in Woodford county is made up of Yellow Silt Loam, much of which is subject to erosion, it is believed that an account of some experiments on the Vienna field will be of interest here.

In 1906 the University acquired a 16-acre tract of badly eroded land characteristic of the region near Vienna in Johnson county. The whole area with the exception of about three acres had been abandoned because so much of the surface soil had washed away and there were so many gullies as to render further cultivation of this land unprofitable. Experiments were started at once to reclaim this land, the different methods described below being used for this purpose.

The field was divided into five sections. The sections designated as A, B, and C were divided into four plots each, and D into three plots. On section A, which included the steepest part of the area and contained many gullies, the land was built up into terraces at vertical intervals of 5 feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

On Section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges sufficiently high so that on the occasion of a heavy rainfall, if the water breaks over, it will run over in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two excep-

FIG. 3.—VIEW OF AN UNIMPROVED HILLSIDE JUST OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 4

tions, about 8 loads of manure per acre were turned under each year for the corn crop.

The land on section D was washed to about the same extent as that of section C. As a check on the different methods of reducing erosion, the land on section D was farmed in the most convenient way, without any special effort being made to prevent washing.

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

Sections A, B, C, and D was not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil

FIG. 4.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD. THIS LAND FORMERLY HAD BEEN BADLY ERODED. COMPARE WITH FIG. 3

material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except D, which had but three plots.

The results shown in Table 14 indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn

TABLE 14.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

from the protected series (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels for series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 3 and 4 will serve to indicate the possibility of improving this type of soil.

THE OQUAWKA FIELD

In 1913 the University established an experiment field on Dune Sand, Terrace, in Henderson county, near the Mississippi river. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted. Table 15 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 42.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite indifferent to treatment with rock phosphate. The analyses show, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

Altho the results show an increase of 2.9 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment.

The slight increases or decreases appearing in the other crops probably lie within the experimental error.

A significant fact which the general summary does not bring out is that the improvement under favorable treatment has been progressive, as evidenced by a very marked upward trend in production after the first few years. For example, we note that the yield of corn under the limestone-residues treatment has been 36.7 bushels an acre as an average for the 11 crops since full treatment started, but if we take an average of the last five crops the yield rises to 45.7 bushels. Likewise the average yield of wheat under this same treatment is 13.9 bushels for the eleven-year period, but the average for the last five years is 19.6 bushels.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

Manure
Yield: nothing

Manure and limestone
Yield: 4.43 tons an acre

FIG. 5.—ALFALFA ON THE OQUAWKA FIELD

These pictures show the possibility of improving this unproductive sandy land of the Oquawka field. Both plots were seeded alike to alfalfa. Where manure alone was applied, the crop was a total failure, but where limestone in addition to manure was applied, nearly 4½ tons of alfalfa hay was obtained as the season's yield.

TABLE 15.—OQUAWKA FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1915-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *11crops*	Soybeans[1] *11crops*	Wheat *11 crops*	Sweet Clover[2] *7 crops*	Rye *9 crops*	Alfalfa *8 crops*
1	0	19.8	(1.01)	7.7	0.00	11.9	(.35)
2	M	25.0	(1.20)	10.9	0.00	13.3	(.56)
3	ML	32.2	(1.60)	14.6	1.14	24.5	(2.05)
4	MLrP	31.9	(1.58)	15.0	1.14	23.0	(2.12)
5	0	20.1	(.78)	9.8	0.00	11.7	(.08)
6	R	21.8	(.76)	11.1	0.00	12.7	(.09)
7	RL	36.7	(1.25)	13.9	1.57	24.3	(1.82)
8	RLrP	36.1	(1.25)	14.1	1.43	24.3	(1.79)
9	RLrPK	39.0	(1.17)	13.3	1.67	26.5	(1.87)
10	0	19.1	(.72)	8.8	0.00	10.7	(.02)
	M over 0	5.2	(.19)	3.2	0.00	1.4	(.21)
	R over 0	1.7	−(.02)	1.3	0.00	1.0	−(.01)
	ML over M	7.2	(.40)	3.7	1.14	11.2	(1.49)
	RL over R	14.9	(.49)	2.8	1.57	11.6	(1.73)
	MLrP over ML	−.3	−(.02)	.4	0.00	−1.5	(.07)
	RLrP over RL	−.6	0.00	.2	−.14	0.0	−(.03)
	RLrPK over RLrP	2.9	−(.08)	−.8	.24	2.2	(.08)

[1]Eleven regular crops, together with the extra crop described in footnote 2, averaged as 11 crops. Several crops which were harvested as seed are evaluated in this summary as hay.

[2]Some hay evaluated as seed. In 1918, the sweet clover was killed by early cutting for a hay crop. Soybeans were seeded in July and the ensuing crop is included in the soybean averages.

THE MANITO FIELD

The results secured on the Manito experiment field, which was located on Deep Peat and which was in operation during the years 1902 to 1905 inclusive, are presented in Table 16.

There were 10 plots receiving the treatments indicated in the table. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. However, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons an acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the total yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) appear to be insufficient.

TABLE 16.—MANITO FIELD: ANNUAL CROP YIELDS
Bushels per acre

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905
1	None	10.9	8.1	None	17.0	12.0
2	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs. Kainit, 1200 lbs	49.6	47.3
4	Kainit, 600 lbs Acidulated bone, 350 lbs	30.3	33.3	Kainit, 1200 lbs Steamed bone, 395 lbs.	53.5	47.6
5	Potassium chlorid, 200 lbs	31.2	33.9	Potassium chlorid, 400 lbs	48.5	52.7
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs.	44.5	47.3
8	Kainit, 600 lbs	36.8	37.7	Kainit, 600 lbs	44.0	46.0
9	Kainit, 300 lbs	26.4	25.1	Kainit, 300 lbs.	41.5	32.9
10	None	[1]	14.9	None	26.0	13.6

[1]No yield was taken in 1902 because of a misunderstanding.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1925
33 Saline, 1926
34 Marion, 1926
35 Will, 1926
36 Woodford, 1927

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Agricultural Experiment Station

SOIL REPORT No. 37

LEE COUNTY SOILS

By R. S. SMITH, O. I. ELLIS, E. E. DeTURK, F. C. BAUER, and L. H. SMITH

URBANA, ILLINOIS, JUNE, 1927

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Lee county was conducted.

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LEE COUNTY SOILS

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LEE COUNTY SOILS

By R. S. SMITH, O. I. ELLIS, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

LOCATION AND CLIMATE OF LEE COUNTY

Lee county is located in the northwestern part of Illinois. Dixon, the county seat, is about 100 miles west of Chicago. Lee county is of average size, consisting approximately of 723 square miles, two-thirds of which is in the upland.

The climate of Lee county is typical of the general region in which it lies. It is characterized by a wide range between the extremes of winter and summer, and by the abundant, well-distributed rainfall. The greatest range in temperature in any one year from 1892 to 1924 was 126 degrees in 1905. The highest temperature recorded was 108° in 1901; the lowest, 26° below zero in 1905. The average date of the last killing frost in spring is April 28; the earliest in fall is October 11. The average length of the growing season, therefore, is 165 days.

The average rainfall as recorded at Dixon from 1892 to 1924 was 32.29 inches. The average rainfall by months for this period was as follows: January, 1.61 inches; February, 1.35; March, 2.64; April, 2.57; May, 4.31; June, 3.70; July, 3.82; August, 3.29; September, 3.56; October, 2.37; November, 1.62; December, 1.45.

AGRICULTURAL PRODUCTION

Grain, livestock, dairying, and mixed grain and livestock farming characterize the agriculture of the county. The mixed system of farming is most extensively practiced. In this system the chief sources of income are dairy products, beef cattle, and hogs, with a supplementary income from the sale of surplus grain and hay.

The livestock industry has been increasing in importance during the past few years, particularly in the corn-belt section in the eastern part of the county. A contributing cause for this is the danger of injury to the corn from early frosts. It apparently is more profitable to feed the crop than it is to attempt to harvest and sell the grain. The dairy industry is predominant near the towns of Dixon, Amboy, Nachusa, and Harmon. Very few creameries have been constructed in the farming communities. The milk is hauled to the central condensing plants. In the extreme eastern and southeastern parts of the county grain farming is followed. In the section south and west of Amboy, known as the Green river swamp, diversified grain farming and mixed livestock feeding are the chief systems. Often on a single farm, corn, oats, wheat, rye, and barley are grown. Alfalfa, sweet clover, and red clover give good returns, altho it is necessary to apply limestone on most of the soils to insure a good catch of the legumes.

Since the acreage of rough and broken land is not large, a very small percentage of natural grazing land occurs. In some cases, the rough and broken land is partially utilized for cultivated crops, thus further reducing the acreage

[1] R. S. Smith, in charge of soil survey mapping; O. I. Ellis, Assistant Chief in soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

which might well be used for pasture. Fruit and vegetables are grown only for home consumption.

According to the Fourteenth Census of the United States, there were 2,593 farms in the county in 1919. The average size was 167 acres, 151.5 of which were improved. The following table shows the acreage and yield of the more important crops for the year 1919, as given by the above-mentioned Census.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	141,639	5,412,822 bu.	38.2 bu.
Oats	86,921	2,554,104 bu.	29.3 bu.
Wheat	26,391	503,293 bu.	19.1 bu.
Rye	11,887	167,743 bu.	14.1 bu.
Barley	7,609	179,806 bu.	23.6 bu.
Timothy	37,346	53,906 tons	1.44 tons
Timothy and clover	11,582	14,360 tons	1.23 tons
Clover	22,111	32,753 tons	1.48 tons
Alfalfa	2,672	4,515 tons	1.72 tons
Silage crops	7,058	56,192 tons	7.94 tons
Corn for forage	6,501	16,989 tons	2.59 tons

It should be borne in mind that the above figures represent the yields of only a single season.

The U. S. Department of Agriculture furnishes the following acre-yields for the ten-year period 1911-1920: corn, 41.0 bushels; oats, 42.3 bushels; tame hay, 1.3 tons; winter wheat, 20.4 bushels. Thus it appears that the census year, 1919, was an unfavorable one for corn and oats.

The following figures taken from the 1920 Census show the character of the livestock interests in Lee county. The total value of livestock was $7,434,370 in 1919.

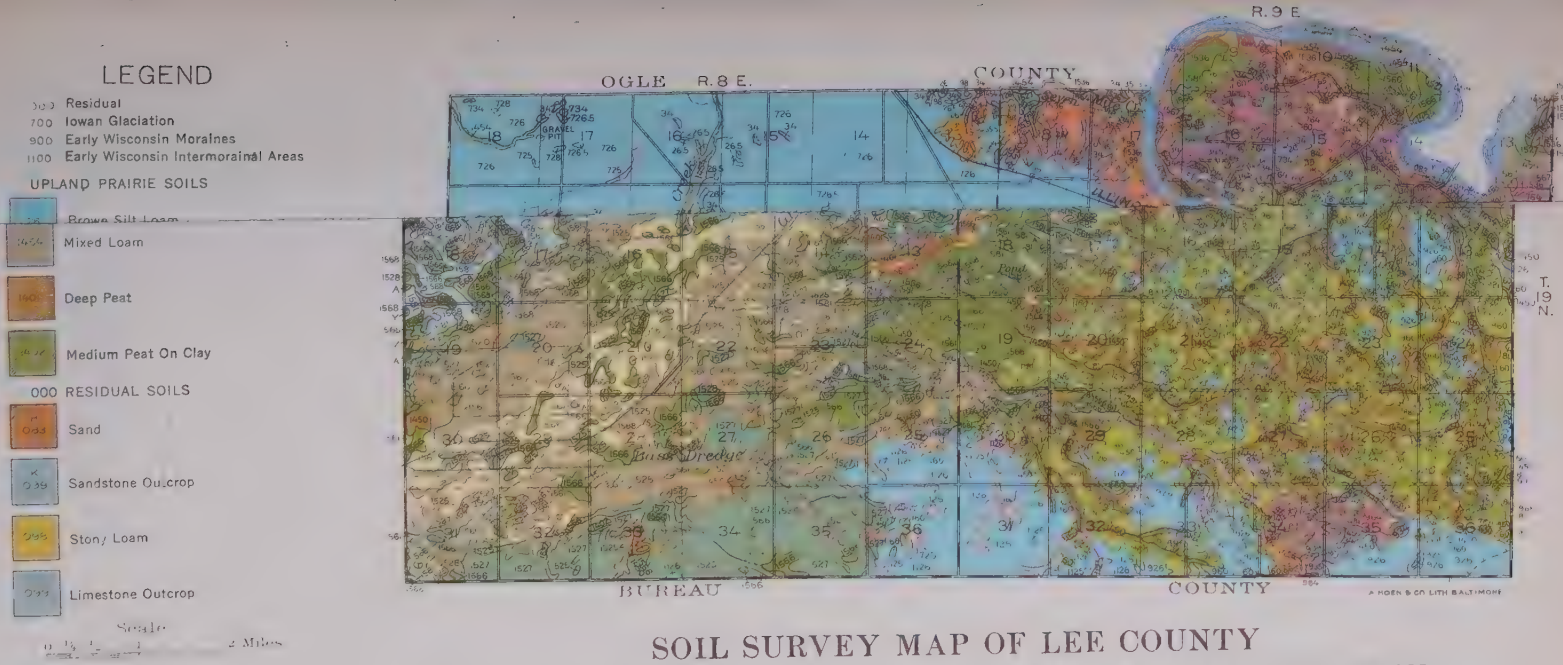
Animals and Animal Products	*Number*	*Value*
Horses	18,959	$1,793,915
Mules	559	62,004
Beef cattle	29,145	1,963,830
Dairy cattle	21,493	1,659,640
Swine	61,034	1,461,841
Sheep	11,512	160,507
Poultry	319,522	334,633
Eggs and chickens	.....	430,219
Dairy products	.....	1,111,160

Rock and acid phosphate, mixed fertilizers, and limestone have been used rather extensively thruout the county. The use of limestone has increased rapidly during the past few years.

SOIL FORMATION

GLACIATION

One of the most important periods in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during which and immediately following, the material that later formed the mineral portion of the soils was being deposited. At that time, snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an amount that the mass pushed outward from these centers, chiefly southward, until a point was reached where the ice melted as rapidly as it advanced. In moving across the country from the far north, the ice gathered up all sorts and sizes



SOIL SURVEY MAP OF LEE COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

of material, including clay, silt, sand, gravel, boulders, and even immense masses of rock. Some of these materials were carried for hundreds of miles and rubbed against surface rocks and against each other until largely ground into powder. When the limit of advance of the ice sheet was reached, the rock material carried by the ice accumulated along the front of the glacier in a broad, undulating ridge or moraine. When the ice melted more rapidly than the glacier advanced, the terminus of the glacier receded, and the material was deposited somewhat irregularly over the area previously covered. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift. The average depth of this deposit over the state of Illinois is estimated as 115 feet.

Lee county is situated in a region of vigorous glacial and stream action. The bed rock is buried so deeply over most of the county that it has no influence on the character of the soil. An exception is found in the northwest corner of the county, west of Rock river, where the thickness of the glacial drift does not exceed three feet over much of the area. Relatively shallow drift also occurs to the north of Franklin Grove and Ashton.

At least two, and possibly three, glaciers advanced across the area now included in Lee county. The first of these was the Illinoisan, which covered the entire county. A sufficiently long period of time elapsed after the retreat of the Illinoisan ice sheet for a thick soil to be formed before the next glacial invasion. This soil is known as the Sangamon soil. It was buried by the next glacier, regarding the identity of which there is considerable question. Some believe it was the Iowan, as indicated on the accompanying soil map; some that it was a lobe of the Illinoisan. Following the retreat of this glacier or ice lobe, as the case may be, the third and last ice invasion took place. This last invasion is known as the early Wisconsin. It covered about one-half of the county and during its advances and retreats it constructed numerous moraines, two of which cross the eastern and southeastern parts of Lee county in a northeast-southwest direction. The main morainal ridge which closely follows the outer border of the swamp region of Lee and Bureau counties is known as the outer belt of the Bloomington moraine. This ridge is from 75 to 100 feet higher than the adjacent flat areas to the north and west. The inner ridge crosses the southeast corner of the county.

CHANGES IN THE RIVER SYSTEMS

The extensive swamp and sand areas in Lee county, together with other features, indicate that there have been great changes in the river systems in this region since Preglacial times. The Preglacial course of Rock river was south from Rockford in Winnebago county thru Rochelle in Ogle county and then in a general southwesterly direction to Illinois river in Bureau county. During the Glacial period the Preglacial Rock river was diverted to its present course at its junction with Kishwaukee river in southeastern Winnebago county. This new course was cut thru sandstone and limestone and the conditions were such that no extensive terraces were constructed, such as were formed along the Preglacial course.

Other extensive changes in the drainage systems of the region have occurred, the net result of all the changes being the deep alluvial fills such as occur in the Inlet swamp northeast of Amboy and in the Green river basin.

PHYSIOGRAPHY AND DRAINAGE

The topographic features of Lee county present considerable variation because of the changes which have taken place in its drainage systems. The county constitutes an undulating to rolling plain which becomes rough and hilly as the north-central and northwestern parts of the county are approached. This plain is bisected by the Green river drainage basin, part of which marks the course of the Preglacial Rock river. This drainage basin, locally known as the Green river and Inlet swamp basins, varies in topography from flat to undulating.

Rock river, Green river, and Bureau creek, with their tributaries, form the main drainage systems of the county. Of these, Green river is of chief importance. The channel of this stream has been deepened and straightened, thus providing satisfactory drainage for the swampy condition which formely existed thruout the area now effectively drained by this stream. The accompanying drainage map shows clearly the drainage lines of the county.

The following altitudes of a few places will give some idea of the general elevation of Lee county: Amboy, 753; Ashton, 817; Dixon, 725; Franklin Grove, 810; Nachusa, 790; Paw Paw, 928; Sublette, 924.

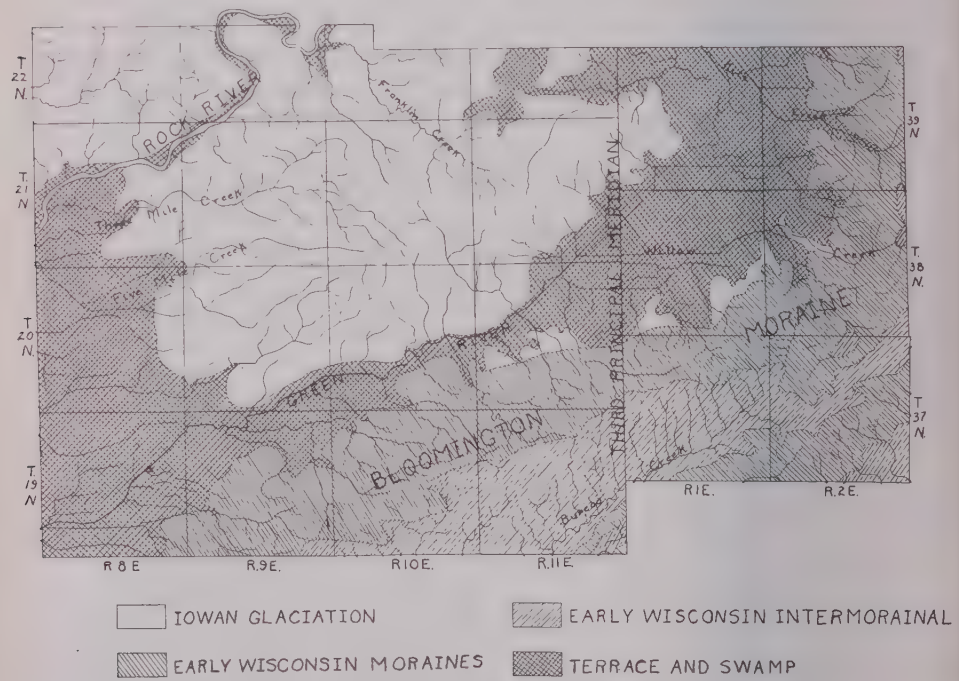


FIG. 1.—DRAINAGE MAP OF LEE COUNTY SHOWING STREAM COURSES, GLACIATIONS, AND TERRACE AND SWAMP AREAS

LEGEND

000 Residual
700 Iowan Glaciation
900 Early Wisconsin Moraines
1100 Early Wisconsin Intermorainal Areas

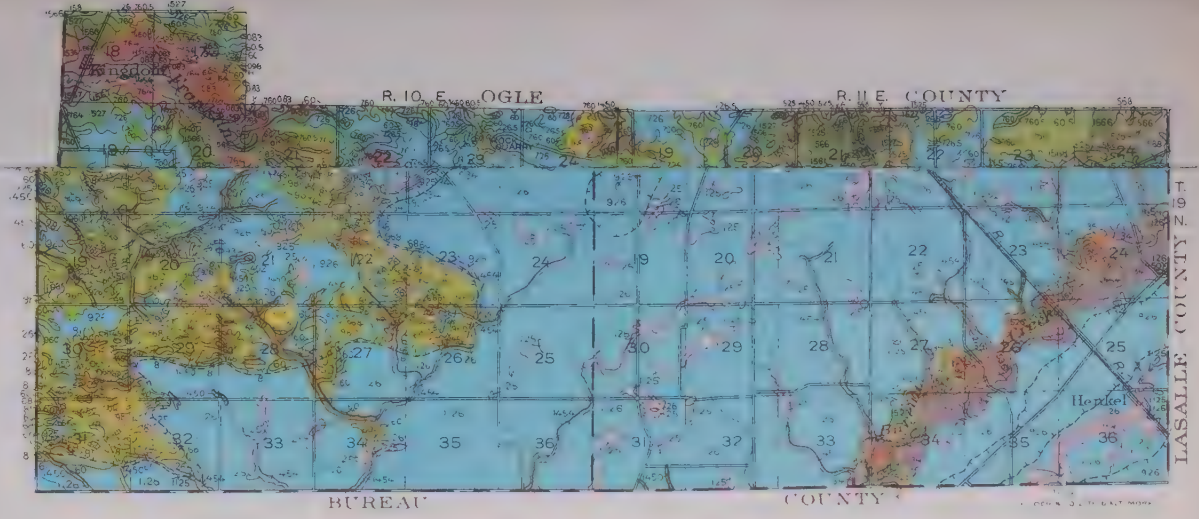
UPLAND PRAIRIE SOILS

- 154 Mixed Loam
- 140 Deep Peat
- 160 Medium Peat On Clay

000 RESIDUAL SOILS

- 083 Sand
- 039 Sandstone Outcrop
- 098 Stony Loam
- 013 Limestone Outcrop

Scale
0 ¼ ½ 1 2 Miles



SOIL SURVEY MAP OF LEE COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

SOIL DEVELOPMENT

During the time which has elapsed since the last ice invasion, weathering and other processes have been active, resulting in the formation of the soils of the county as we know them today. When first deposited, the general composition of any soil material, particularly loess, is rather uniform. With the passing of time, however, various physical, chemical, and biological agencies of weathering form soil out of the parent material by some or all of the following processes: the leaching of certain elements, the accumulation of others; the chemical reduction of certain compounds, the oxidation of others; the translocation of the finer soil particles, and the arrangement of them into zones or horizons; and the accumulation of organic matter from the growth and decay of vegetable material. One of the very pronounced characteristics observed in most soils is that they are composed of more or less distinct strata, called horizons. As explained somewhat more fully in the Appendix, these horizons are named, from the surface down: A, the layer of extraction; B, the layer of concentration or accumulation; and C, the layer of less-altered material, or the layer in which weathering has had less effect. The development of horizons in a soil is an indication of its age.

Since the upland prairie of this region has been occupied, probably continuously, by grass vegetation, relatively large amounts of organic matter have accumulated, resulting in the formation of productive dark-colored soils. The areas adjacent to streams, which have been occupied by timber, are light-colored because of the relative deficiency of the surface soil in organic matter. The bottom-land soils are made up, for the most part, of alluvial material brought down from the uplands of the immediate vicinity. These soils are to be regarded as relatively young or immature and therefore have not developed horizons as have the mature soils of the upland.

SOIL GROUPS

The soils of Lee county are divided into the following groups:

Upland Prairie Soils, including the dark-colored upland soils.

Upland Timber Soils, including the light-colored upland soils.

Terrace Soils, including alluvial deposits now above overflow.

Swamp and Bottom-Land Soils, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

Residual Soils, including rock outcrop areas, and soils formed in place thru weathering of rocks.

Table 1 gives the area of each soil type in Lee county and its percentage of the total area. It will be observed that 61.23 percent of the county consists of upland prairie, 5.44 percent of upland timber, 26.22 percent of terrace, 6.49 percent of swamp and bottom-land soils, and .14 percent of residual soils.

The accompanying map, appearing in three sections, shows the location and boundary lines of the various types.

For explanation concerning the classification of soils and interpretation of the maps and tables, the reader is referred to the first part of the Appendix to this Report.

TABLE 1.—SOIL TYPES OF LEE COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils (700, 900, 1100)			
726, 926, 1126	Brown Silt Loam	350.89	224 571	48.49
726.5	Brown Silt Loam On Limestone	1.54	986	.21
760, 960, 1160	Brown Sandy Loam	42.79	27 384	5.91
760.5	Brown Sandy Loam On Limestone	.07	45	.01
728	Brown-Gray Silt Loam On Tight Clay	5.64	3 610	.77
768	Brown-Gray Sandy Loam On Tight Clay	3.96	2 534	.54
725, 925, 1125	Black Silt Loam	30.14	19 290	4.16
781, 981	Dune Sand	8.15	5 215	1.12
790	Gravelly Loam	.18	116	.02
		443.36	283 751	61.23
	Upland Timber Soils (700, 900, 1100)			
734, 934, 1134	Yellow-Gray Silt Loam	25.31	16 198	3.49
735, 935, 1135	Yellow Silt Loam	4.34	2 778	.59
764, 964	Yellow-Gray Sandy Loam	6.83	4 372	.94
765	Yellow Sandy Loam	.76	486	.14
734.5	Yellow-Gray Silt Loam On Limestone	.56	358	.08
735.5	Yellow Silt Loam On Limestone	1.43	915	.20
		39.23	25 107	5.44
	Terrace Soils (1500)			
1527	Brown Silt Loam Over Gravel	52.51	33 607	7.26
1525	Black Silt Loam	54.89	35 130	7.58
1561	Black Sandy Loam	34.37	21 996	4.75
1566	Brown Sandy Loam Over Gravel	30.12	19 276	4.16
1520	Black Clay Loam	1.52	973	.21
1536	Yellow-Gray Silt Loam Over Gravel	2.45	1 569	.33
1567	Yellow-Gray Sandy Loam Over Gravel	2.33	1 491	.32
1528	Brown-Gray Silt Loam On Tight Clay	.59	378	.08
1568	Brown-Gray Sandy Loam On Tight Clay	3.31	2 118	.46
1581	Dune Sand	7.45	4 768	1.03
1562	Gray Sandy Loam	.27	173	.04
		189.81	121 479	26.22
	Late Swamp and Bottom-Land Soils (1400)			
1450	Black Mixed Loam	25.27	16 172	3.49
1454	Mixed Loam	18.93	12 115	2.62
1401	Deep Peat	2.57	1 645	.36
1402	Medium Peat On Clay	.15	96	.02
		46.92	30 028	6.49

TABLE 1.—SOIL TYPES OF LEE COUNTY, ILLINOIS—*Concluded*

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Residual Soils (000)			
083	Sand	.65	416	.09
099	Sandstone Outcrop	.06	38	.01
098	Stony Loam	.15	96	.02
099	Limestone Outcrop	.15	96	.02
		1.01	646	.14
	Miscellaneous			
	Water	3.08	1 972	.43
	Quarries	.27	172	.04
	Gravel pits	.08	51	.01
		3.43	2 195	.48
	Total	723.76	463 206	100.00

INVOICE OF THE ELEMENTS OF PLANT FOOD IN LEE COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). These sampling strata correspond approximately in the common kinds of soil to 2 million pounds per acre of dry soil in the upper stratum, and to two times and three times this quantity in the middle and lower strata, respectively. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to in describing the soil types as horizons A, B, and C. By this system of sampling we have represented separately three zones for plant feeding. The upper, or surface layer, includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, phosphate, or other fertilizing materials are incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed. It should be understood, however, that the rate of liberation from their insoluble forms, a matter of at least equal importance, is governed by many factors, and is therefore not necessarily proportional to the total amounts present.

For convenience in making application of the chemical analyses, the results as presented here have been translated from the percentage basis and are given

in the accompanying tables in terms of pounds per acre. In this, the assumption is made that for ordinary types a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2 million pounds. It is understood, of course, that this value is only an approximation, but it is believed that with this understanding, it will suffice for the purpose intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires to consider the information in that form.

With respect to the presence of limestone and acidity in different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages for the respective types, because of the extreme variations frequently found within a given soil type. In examining each soil type in the field, however, numerous qualitative tests are made which furnish general information regarding the soil reaction, and in the discussion of the individual soil types which follow, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping and soil treatment. Therefore it is often desirable to determine the lime requirement for a given field and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (page 38).

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amounts of organic carbon, nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil of each type in Lee county.

In connection with this table attention is called to the variation among the soil types with respect to their content of the different plant-food elements. It will be seen from the analyses that variations in the organic-carbon content of the different soils are accompanied by a parallel variation in the nitrogen content. The organic-carbon content, which serves as a measure of the total organic matter present, is usually from 10 to 12 times that of the total nitrogen. This relationship is explained by the well-established facts that all soil organic matter contains nitrogen, and that most of the soil nitrogen (usually 98 percent or more) is present in a state of organic combination. This close relationship is also maintained in the middle and lower sampling strata.

The range in content of organic matter and nitrogen is very wide. The upland prairie soils are for the most part relatively high in these constituents. The upland timber soils are generally fairly low, altho there is some overlapping of organic matter in the two groups of soil types. The upland timber soils range from 13,140 pounds of organic carbon an acre in Yellow Silt Loam On Limestone up to 38,260 pounds in Yellow-Gray Silt Loam, with an average of 24,140 pounds. The upland prairie soils, ranging from 23,130 to 123,940 pounds, average 56,410 pounds, or more than twice the amount found in the former group. One type, Dune Sand, is omitted from the average for upland prairie soils as given above. This type, as is usually the case with very sandy soils, is very deficient in organic matter and nitrogen, the organic carbon amounting to only

LEGEND

000 Residual
700 Iowan Glaciation
Early Wisconsin Moraines

454 Mixed Loam

1401 Deep Peat

140 Medium Peat On Clay

000 RESIDUAL SOILS

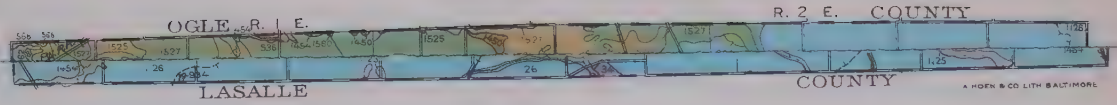
M 083 Sand

K 098 Sandstone Outcrop

098 Stony Loam

099 Limestone Outcrop

Scale
0 ¼ ½ 1 2 Miles



SOIL SURVEY MAP OF LEE COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

15,780 pounds an acre in the surface stratum. While most soils should receive regular additions of organic materials in the form of green or animal manures and crop residues in order to maintain an adequate supply of organic matter in actively decomposing condition, the frequent use of such materials is particularly necessary in the management of Dune Sand and similar types. The porous, open character of these sandy soils permits the rapid oxidation of organic matter, so that it disappears from the soil much more rapidly than from the heavier types. Dune Sand is in fact but little more than the skeleton of a soil and cannot readily be brought up to, and maintained in, a state of productiveness without first getting an accumulation of organic matter in it, and continuing with frequent subsequent additions. The soil is usually acid and hence limestone and legume green manures constitute the first and most important steps in converting it into a productive soil.

Black Silt Loam contains the largest amount of organic carbon of any soil in the county, except Deep Peat, which is made up largely of organic matter. The organic carbon of Black Silt Loam amounts to 123,940 pounds an acre, with a corresponding nitrogen content of 16,440 pounds. While such soils as this will withstand more abuse by the practice of continuous cropping and are not so greatly in need of additions of organic materials as are soils containing 20,000 to 30,000 pounds of organic carbon, yet the use of manure and the systematic growing of legumes for pasture and plowing down serve to renew the active organic material in the soil in a way which is reflected in increases of crop yields.

Other elements are not so closely associated with each other as are organic matter and nitrogen. There is some degree of correlation, however, between sulfur, another element used by growing plants, and organic carbon. This is because a considerable, tho varying, proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of the organic matter. Most of the Lee county soils are fairly well supplied with sulfur. It ranges, in the surface soil, from a minimum of 240 pounds an acre in the residual Sand up to 4,890 pounds in Deep Peat. Excluding Deep Peat, the sulfur content of Lee county soils averages approximately half that of phosphorus. The sulfur available to crops is affected not only by the soil supply, but also by that brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently it is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption, the amount of sulfur thus added to the soil is relatively large. At Urbana, during the eight-year period from 1917 to 1924 there has been added to the soil by the rainfall 3.5 pounds of sulfur an acre a month as an average. Similar observations have been made in other localities for shorter periods. At Spring Valley, in Bureau county, the rainfall during six summer months in 1921 brought down 34.5 pounds of sulfur an acre, or an average monthly precipitation of 5.75 pounds. The maximum for a single month was 8.77 pounds, in June. At Toledo, Cumberland county, from April to November, 1922, the average precipitation was 3 pounds an acre a month. The precipitation at the various points in the state in a single month has varied from a minimum of .74 of a pound to

10.22 pounds an acre. These figures will afford some idea of the amounts of sulfur added by rain and also of the wide variation in these amounts under different conditions. On the whole these facts would indicate that the sulfur added from the atmosphere supplements that contained in the soil, so that there appears to be little or no need for sulfur fertilizers in Lee county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started at five experimental fields, namely, Raleigh, Toledo, Carthage, Hartsburg, and Dixon.

The upland timber soils are, on the whole, more deficient in total phosphorus than either the upland prairie or the terrace soils, altho one of the poorest types in the county in this respect is Dune Sand in the prairie, with an average phosphorus content of 540 pounds.

One type, Black Silt Loam, is outstanding in the county for its high phosphorus content. As found in the upland prairie group, the surface soil of this type contains 3,630 pounds of phosphorus in an acre, while the samples collected in the terrace contained 3,250 pounds. This soil type not only exhibits an unusually high phosphorus content, but is high in organic matter, nitrogen, calcium, and magnesium as well, and is fairly well supplied with sulfur. As to extent, this type covers, in the upland and terrace regions combined, 85 square miles, or 11.74 percent of the area of the county.

Potassium is deficient in Deep Peat, as is usually the case with this soil type, the total amount in the upper 6⅔ inches of soil being only 4,430 pounds an acre. The sandy types in Lee county are considerably lower in potassium content than is generally the case.

Residual Sand has only 6,880 pounds of potassium an acre; Dune Sand, Terrace, 13,020 pounds; and the other sands and sandy loams vary around the 20,000-pound level. Sand soils carry a large proportion of their potassium content in the coarse sand grains. The relatively small total surface exposed in the case of the coarse particles greatly lowers the solubility and availability of the potassium in sand soils. This is partly offset, however, by the greater depth of the feeding zone for crop roots in sandy soils as compared with the heavier types. The other types are normal in content of potassium.

The variation in the calcium and magnesium content in the soils of this county is wide. Nearly all the sand and sandy loam types are markedly low in both calcium and magnesium, containing, generally, less than 4,000 pounds in the surface 6⅔ inches. The soils of finer texture are fairly well supplied with both of these elements.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper stratum, or with each other, it is necessary to bear in mind that the data as given for the middle and lower sampling strata are on the basis of 4 million and 6 million pounds of soil, and should therefore be divided by two and three respectively before being compared with each other or with the data for the upper stratum, which is on a basis of 2 million pounds.

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF LEE COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES
Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
Upland Prairie Soils (700, 900, 1100)								
726, 926, 1126	Brown Silt Loam	62 520	5 550	1 350	1 050	32 020	8 020	10 280
726.5	Brown Silt Loam On Limestone	46 760	3 780	1 060	900	32 000	5 800	7 060
760, 960	Brown Sandy Loam	23 130	2 490	900	630	22 690	3 510	3 710
760.5	Brown Sandy Loam On Limestone	33 760	2 860	1 280	620	23 440	4 600	2 920
728	Brown-Gray Silt Loam On Tight Clay	48 360	4 040	1 100	720	25 430	3 870	4 340
768	Brown-Gray Sandy Loam On Tight Clay[1]							
725	Black Silt Loam	123 940	16 440	3 630	1 980	42 570	12 410	13 930
781	Dune Sand	15 780	1 160	540	400	18 240	1 240	3 460
790	Gravelly Loam[1]							
Upland Timber Soils (700, 900, 1100)								
734, 934	Yellow-Gray Silt Loam	38 260	2 480	960	660	37 210	5 990	9 540
735	Yellow Silt Loam	29 040	2 500	860	460	37 420	5 780	7 820
764	Yellow-Gray Sandy Loam	25 900	2 560	740	480	27 060	3 040	5 640
765	Yellow Sandy Loam	16 680	1 160	840	360	21 400	2 800	4 620
734.5	Yellow-Gray Silt Loam On Limestone	21 820	1 640	640	320	30 140	4 200	6 400
735.5	Yellow Silt Loam On Limestone	13 140	2 940	840	500	34 500	4 900	8 360
Terrace Soils (1500)								
1527	Brown Silt Loam Over Gravel	49 300	4 000	1 590	780	35 190	7 650	4 690
1525	Black Silt Loam	75 510	6 970	3 250	1 020	30 710	12 210	17 930
1561	Black Sandy Loam	88 260	7 900	1 240	1 120	21 180	3 800	9 960
1566	Brown Sandy Loam Over Gravel	30 060	3 240	950	640	19 110	4 300	4 180
1520	Black Clay Loam	95 640	8 780	2 320	1 420	31 140	14 880	22 800
1536	Yellow-Gray Silt Loam Over Gravel	31 940	2 820	2 120	620	36 760	6 780	6 780
1567	Yellow-Gray Sandy Loam Over Gravel	23 320	1 800	1 120	420	22 800	4 100	3 320
1528	Brown-Gray Silt Loam On Tight Clay	47 740	4 060	1 260	680	25 900	4 900	8 740
1568	Brown-Gray Sandy Loam On Tight Clay	71 700	6 300	1 460	940	22 900	3 880	3 080
1581	Dune Sand	12 840	940	740	280	13 020	1 580	2 400
1562	Gray Sandy Loam	35 240	2 940	1 000	620	17 780	3 940	2 220
Late Swamp and Bottom-Land Soils (1400)								
1450	Black Mixed Loam[2]							
1454	Mixed Loam[2]							
1401	Deep Peat[3]	403 510	44 360	1 910	4 890	4 430	4 180	26 930
1402	Medium Peat On Clay[3]	282 370	22 700	2 180	2 850	9 090	6 470	23 530
Residual Soils (000)								
083	Sand	14 140	600	480	240	6 880	160	1 900
098	Stony Loam	66 540	6 380	1 500	1 380	39 580	60 180	90 540

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]No samples were obtained.

[2]Analytical results are not included for Mixed Loam and Black Mixed Loam because of the heterogeneity of these types.

[3]Amounts reported are for 1 million pounds of Deep Peat and Medium Peat On Clay.

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF LEE COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (700, 900, 1100)							
726, 926, 1126	Brown Silt Loam	58 310	5 920	2 030	1 390	61 580	18 410	18 590
726.5	Brown Silt Loam On Limestone	54 560	4 480	1 840	1 520	68 160	14 480	11 920
760, 960	Brown Sandy Loam	51 570	3 490	1 750	930	50 710	10 200	7 760
760.5	Brown Sandy Loam On Limestone	35 720	3 160	1 720	920	42 880	10 160	5 120
728	Brown-Gray Silt Loam On Tight Clay	31 820	3 020	1 540	620	57 540	11 300	8 920
768	Brown-Gray Sandy Loam On Tight Clay[1]							
725	Black Silt Loam	94 000	8 760	3 300	1 620	62 700	25 240	36 800
781	Dune Sand	26 480	1 880	1 120	840	36 680	2 000	6 440
790	Gravelly Loam[1]							
	Upland Timber Soils (700, 900, 1100)							
734, 934	Yellow-Gray Silt Loam	49 740	2 620	1 480	980	72 040	18 280	16 780
735	Yellow Silt Loam	21 960	2 280	1 960	640	85 920	24 440	16 680
764	Yellow-Gray Sandy Loam	19 440	1 800	1 120	680	55 720	9 240	11 000
765	Yellow Sandy Loam	13 640	1 120	1 280	360	47 640	7 200	10 440
734.5	Yellow-Gray Silt Loam On Limestone	17 800	1 520	1 200	560	57 920	10 280	11 400
735.5	Yellow Silt Loam On Limestone	24 840	3 000	1 960	720	71 520	13 440	18 720
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	57 800	5 100	2 420	1 220	72 860	18 460	11 140
1525	Black Silt Loam	76 240	6 330	2 830	940	65 240	25 310	34 560
1561	Black Sandy Loam	54 920	4 520	1 160	880	41 240	5 680	11 160
1566	Brown Sandy Loam Over Gravel	51 140	4 040	2 080	940	44 600	11 520	7 240
1520	Black Clay Loam	84 480	7 960	3 560	1 640	65 040	38 000	58 440
1536	Yellow-Gray Silt Loam Over Gravel	29 000	2 800	3 240	720	74 000	16 600	15 040
1567	Yellow-Gray Sandy Loam Over Gravel	18 000	1 240	2 200	600	44 120	9 480	3 400
1528	Brown-Gray Silt Loam On Tight Clay	40 240	3 800	2 200	920	51 520	15 480	4 480
1568	Brown-Gray Sandy Loam On Tight Clay	28 160	2 600	3 640	880	49 760	7 600	5 840
1581	Dune Sand	14 400	560	1 040	320	32 080	3 720	4 920
1562	Gray Sandy Loam	21 360	2 160	2 040	800	41 400	11 080	2 040
	Late Swamp and Bottom-Land Soils (1400)							
1450	Black Mixed Loam[2]							
1454	Mixed Loam[2]							
1401	Deep Peat[3]	779 780	86 020	3 060	8 320	9 020	9 800	58 600
1402	Medium Peat On Clay[3]	219 100	18 640	2 060	2 620	30 440	17 120	35 840
	Residual Soils (000)							
083	Sand	11 560	560	1 600	360	11 520	680	200
098	Stony Loam[1]							

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]No samples were obtained.

[2]Analytical results are not included for Mixed Loam and Black Mixed Loams because of the heterogeneity of these two types.

[3]Amounts reported are for 2 million pounds of Deep Peat and Medium Peat On Clay.

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF LEE COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES
Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (700, 900, 1100)							
726, 926, 1126	Brown Silt Loam	47 860	3 300	2 630	1 160	102 300	45 570	48 350
726.5	Brown Silt Loam On Limestone							
760, 960	Brown Sandy Loam	28 540	2 760	1 660	1 080	91 800	32 500	34 460
760.5	Brown Sandy Loam On Limestone							
728	Brown-Gray Silt Loam On Tight Clay	24 330	2 520	2 010	720	78 760	21 540	16 500
768	Brown-Gray Sandy Loam On Tight Clay[1]							
725	Black Silt Loam	45 300	3 810	4 260	1 080	108 300	40 110	44 910
781	Dune Sand	24 720	2 340	1 140	900	69 720	10 740	10 980
790	Gravelly Loam[1]							
	Upland Timber Soils (700, 900, 1100)							
734, 934	Yellow-Gray Silt Loam	25 800	2 550	2 910	1 440	118 320	51 480	108 090
735	Yellow Silt Loam	27 780	3 180	3 540	480	146 520	48 480	123 000
764	Yellow-Gray Sandy Loam	15 000	1 380	1 980	780	68 040	16 500	13 700
765	Yellow Sandy Loam	15 060	1 140	2 220	1 140	53 640	11 580	11 160
734.5	Yellow-Gray Silt Loam On Limestone							
735.5	Yellow Silt Loam On Limestone							
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	31 020	3 030	2 580	1 200	92 460	31 250	26 340
1525	Black Silt Loam	46 380	3 760	4 180	1 020	91 510	37 920	37 180
1561	Black Sandy Loam	16 740	1 440	1 140	600	55 560	8 520	13 860
1566	Brown Sandy Loam Over Gravel	26 730	2 040	3 810	1 290	62 880	17 460	7 860
1520	Black Clay Loam	66 120	5 940	4 620	1 680	93 420	75 240	216 960
1536	Yellow-Gray Silt Loam Over Gravel	24 600	1 920	3 240	720	88 380	22 380	29 520
1567	Yellow-Gray Sandy Loam Over Gravel	17 400	1 260	3 300	1 020	49 620	12 360	6 480
1528	Brown-Gray Silt Loam On Tight Clay	24 180	2 400	2 640	840	52 620	17 880	3 280
1568	Brown-Gray Sandy Loam On Tight Clay	30 540	3 000	4 380	600	70 920	17 880	10 440
1581	Dune Sand	16 380	420	1 440	780	45 660	5 100	8 580
1562	Gray Sandy Loam	17 580	1 440	3 180	1 020	45 900	10 980	4 860
	Late Swamp and Bottom-Land Soils (1400)							
1450	Black Mixed Loam[2]							
1454	Mixed Loam[2]							
1401	Deep Peat[3]	1 247 880	125 610	3 180	16 290	15 000	16 740	84 060
1402	Medium Peat On Clay	166 500	10 260	3 180	3 600	109 380	124 140	198 300
	Residual Soils (000)							
083	Sand	14 700	1 080	1 860	720	27 240	2 220	1 500
098	Stony Loam[1]							

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]No samples were obtained.

[2]Analytical results are not included for Mixed Loam or Black Mixed Loam because of the heterogeneity of these types.

[3]Amounts reported are for 3 million pounds of Deep Peat.

Considering the data in this way and comparing the three strata with each other, it will be noted that some of the elements exhibit no consistent change in amount, either upward or downward, with increasing depth. This is true particularly of potassium. Others exhibit more or less marked variation in amount at the different levels. Furthermore, these variations as a rule go in certain general directions, and by a careful study of them it is frequently possible to obtain clues as to the age or stage of maturity of the various soils and the nature of the processes going on in soil formation.

From this point of view it will be seen in comparing the three strata with each other that with the exception of Deep Peat all the soil types diminish rather rapidly in organic matter and nitrogen with increasing depth, and that this diminution is especially noticeable even in the middle stratum. The sulfur content decreases with increasing depth in nearly all cases. This is to be expected since a portion of the sulfur exists in combination with the soil organic matter, which is more abundant in the upper strata, and since inorganic forms of sulfur are not tenaciously retained by the soil against the leaching action of ground water. Phosphorus, on the other hand, is not removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in these forms in plant residues at the expense of the underlying strata. It is the second stratum (6⅔ to 20 inches) which furnishes most of the phosphorus thus moved upward. Consequently, in nearly all of the soil types in Lee county the surface soil contains a larger proportionate amount of phosphorus than the middle stratum, and in the majority of cases more than the lower stratum.

Two important basic elements, calcium and magnesium, have undergone some shifting in the different levels, as exhibited by analyses of upland types. The calcium content, on the whole, is much higher than that of magnesium in the surface soil, indicating a more abundant supply of calcium in the soil-forming materials. The calcium content diminishes in the middle stratum as compared with the upper. This is accompanied by an increase in the magnesium content in both the middle and lower strata. These two elements are unequally removed from the soil by leaching, the calcium being dissolved and carried downward to a greater extent than magnesium. As they are carried downward in solution, magnesium is more readily reabsorbed by the soil mass than calcium, thus forcing the latter out into the solution to be carried farther down. Consequently, while magnesium tends to accumulate in the middle and lower strata, the liberated calcium, which is thus carried farther down than magnesium, may accumulate at still greater depths or may be washed away entirely. These movements of calcium and magnesium, as indicated by the analyses of the different strata, constitute one factor in estimating the relative maturity of the various soil types.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is not possible to obtain this information exactly, especially for the deeper rooted crops, it seems probable that practically the entire feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil

type the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

Considered in this manner the tables reveal that there is not only a wide diversity among the different soils with respect to a given plant-food element, but that there is also a great variation with respect to the relative abundance of the various elements within a given soil type as measured by crop requirements. For example, in the most extensive soil type in the county, Brown Silt Loam, Upland, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 14,770 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus, 6,010 pounds, contained in an acre of the same soil is equivalent to that in 36,000 bushels of corn, while the amount of potassium, 195,900 pounds, is equivalent to that contained in approximately one million bushels of corn. In marked contrast to this soil, with respect to nitrogen, is the Yellow-Gray Silt Loam, an important upland timber soil type, which contains in the 40-inch stratum approximately 7,650 pounds an acre of nitrogen, an amount equal to that in 7,650 bushels of corn. The phosphorus content is nearly as high as in Brown Silt Loam, namely, 5,350 pounds in an acre, which is equivalent to that contained in 31,470 bushels of corn. The potassium content of Yellow-Gray Silt Loam amounts to 227,570 pounds.

With respect to calcium it is not feasible to make such comparisons in soil types which differ within themselves as to the presence or absence of native calcium carbonate (limestone). In such soils the average calcium content cannot be taken as representative of the type. For example, one sample of Yellow-Gray Silt Loam was acid in the lower stratum (20 to 40 inches), the carbonates having been leached to a greater depth than 40 inches. Another sample of the same type contained carbonates in this stratum, and consequently was non-acid. The acid sample contained 31,380 pounds an acre of calcium in this same stratum while the other had more than three times as much, or 108,090 pounds. These differences are thus much greater than the average variations between different soil types.

These considerations are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for factors other than the amount of plant-food elements present enter into consideration. Much depends upon the nature of the crops to be grown, as to their utilization of plant-food materials, and much depends upon the condition of the plant-food substances themselves, as to their availability. Finally, in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon, and in this way contribute fundamental information for the intelligent planning, in a broad way, of systems of soil management for conserving and improving the fertility of the land.

DESCRIPTION OF SOIL TYPES

UPLAND PRAIRIE SOILS

The upland prairie soils of Lee county occupy 443.36 square miles, or 61.23 percent of the area of the county. They are fairly uniformly distributed over the entire county with the exception of the southwest portion, which is occupied by swamp and terrace formations.

These soils vary in color from black to light brown or grayish brown in the surface, and in texture from silts to sands. The subsoils of this group vary in compactness and in other characters as will be noted in the type descriptions to follow.

The dark color of the prairie soils is due to the accumulation of organic matter, which is derived very largely from the fibrous roots of the prairie grasses. The network of grass roots was protected from rapid and complete decay, thru the partial exclusion of oxygen by the covering of fine soil and mat of vegetative material consisting of old grass stems and leaves. This mat of stems and leaves was destroyed in part by prairie fires and by decay; but it was constantly renewed, and while it added but little organic matter to the soil directly, the decay of the prairie grass roots was retarded considerably by it.

Brown Silt Loam (726, 926, 1126)

Brown Silt Loam, Upland, is well distributed over the county. It occupies a total of about 351 square miles, or practically one-half of the area of the county. On the Bloomington moraine south of the Green river swamp and also on the upland north and west of Amboy, this type is spotted with sandy areas. The topography of the type varies from undulating to rolling, the latter condition occurring in the morainic area. Drainage is well developed thruout the greater portion of the Brown Silt Loam area. Some depressions occur in which artificial drainage must be provided to remove the excess water rapidly. In the morainic areas some of the slopes are subject to erosion, so that the organic-matter content is somewhat lower than the average for the type. Thruout the Brown Silt Loam area numerous knolls of sandy loam occur. Many of these are small in size, while others are sufficiently large to be shown on the map. On the moraines the surface soil is usually shallower than it is on the intermorainal areas.

The A_1 horizon, which has an average depth of about 8 inches, is a light to medium brown silt loam. The A_2 horizon, extending to a depth of about 18 inches, varies from a light yellowish brown to a brownish yellow silt loam. The B horizon is a uniform, slightly compact, yellow silt loam with gray joint mottling. The C horizon, below 30 inches, is a friable, yellow silt loam, spotted with bright yellow or red iron concretions.

In the morainic areas glacial till occurs 22 to 36 inches below the surface on the more rolling topography, altho usually on the moraine the glacial drift is found below 40 inches. The drift is a gravelly yellow silt loam.

Management.—The reader is asked to turn to page 49, where he will find the results of the soil experiment field located in Lee county near Dixon. The

soil of this field is not representative of all the soil in Lee county which is mapped as Brown Silt Loam; it is similar, however, to a large percentage of the better drained portions of the type. It will be noted that manure has given excellent returns on this field and that the use of limestone has paid a fairly good profit. The use of rock phosphate has resulted in crop increases just about sufficient to pay for the application of half a ton of this material per acre once in four years. The reader is referred to page 41 for a further discussion of the phosphate problem.

Present knowledge regarding the management of this soil, while not complete, indicates clearly the need for fresh organic matter and, on a considerable portion of the type, an application of limestone. The amount of limestone needed varies and should be determined for each field. The clovers or other legumes should be regularly grown to supply fresh organic matter and nitrogen. At the same time this is being done, trials may well be made of the various phosphates, particularly rock phosphate and acid phosphate. It should be borne in mind in making these trials that, of the grain crops, wheat responds best to phosphate.

Brown Silt Loam On Limestone (726.5)

Brown Silt Loam On Limestone occurs in small, scattered areas thruout the dark-colored soil region in the north-central and northwestern part of the county.

The A_1 horizon is approximately 7 inches in depth and is a brown silt loam. The A_2 horizon is a somewhat compact, brownish yellow, silty clay loam. This stratum gradually becomes heavier with increasing depth and passes into a heavy reddish yellow clay which occurs as a stratum 2 to 3 inches in thickness just above the more or less weathered limestone. The average depth to the limestone is about 16 inches.

Management.—Brown Silt Loam On Limestone, as a type, is not suited to cropping. The underlying bed rock comes so near the surface that the soil is drouthy. It is now, for the most part, kept in permanent pasture, and this practice should be continued. Numerous outcrops occur, some of which are quarried and the stone crushed with portable crushers for agricultural use.

Brown Sandy Loam (760, 960, 1160)

Brown Sandy Loam comprizes 42.79 square miles, or 5.91 percent of the area of the county. Areas of this type occur adjacent to the Green river basin and in the northern part of the county east of Rock river. This type was formed by the blowing of sand out of the sandy swamp and terrace areas of the county onto the upland. South of the Green river swamp there has been little mixing of the wind-blown sand with the upland silty material, while north of the swamps there has been much mixing of the sand with the silts. No abrupt change occurs in this latter region between the sands and silts, while south of the swamps the sands have been piled over and upon the silts with little mixing. The topography of the type varies from undulating to rolling and the natural drainage is good.

The A_1 horizon, which is about 8 inches in depth, is a brown sandy loam. The A_2 horizon, extending from 8 to 18 inches, varies from a light brown to a yellowish brown sandy loam. The B horizon, about 14 inches in thickness, is a slightly compact, yellow, sandy silt loam. The C horizon varies from a yellow silt loam, sandy phase, to a yellow sand. In the morainic area glacial till sometimes occurs at a depth varying from 36 to 45 inches below the surface.

Management.—Brown Sandy Loam, as it is mapped, varies within rather wide limits in sand content. A considerable portion of the type is too sandy to produce satisfactory yields of the grain crops when farmed by the usual methods, and consequently much of it is now left in pasture.

A moderate application of limestone, 2 to 3 tons an acre, should be added to this soil as the first step in raising its level of production. In addition to being slightly acid, this soil is low in nitrogen and organic matter. The character of the soil indicates that this deficiency should be met by the use of short rotations, which will provide for the frequent additions of fresh organic matter in the form of clover, preferably sweet clover. The above plan takes into account the leachy nature of this soil and the impossibility of economically maintaining its organic-matter and nitrogen contents at as high a level as is possible with finer textured soils. It is also suggested that trial be made of acid phosphate for wheat, and of one of the potash salts for corn. Alfalfa can be grown satisfactorily on most, or perhaps all, of this land following the application of limestone.

Brown Sandy Loam On Limestone (760.5)

Brown Sandy Loam On Limestone is of little importance in Lee county because of its very limited area, 45 acres, and its low agricultural value. It is similar, in all respects, to Brown Silt Loam On Limestone with the exception of texture.

Management.—This type should be left in permanent pasture, as its drouthy nature makes it unfit for cropping.

Brown-Gray Silt Loam On Tight Clay (728)

Brown-Gray Silt Loam On Tight Clay is irregularly distributed over the upland. It is frequently found in the low undrained areas of Brown Sandy Loam. It is flat in topography and poorly drained because of its flatness and also because of the presence of the highly plastic "tight clay" subsoil. The type occupies only 5.64 square miles, or less than one percent of the area of the county.

The A_1 horizon, which is 7 to 10 inches in thickness, is usually a grayish brown silt loam, containing an appreciable amount of sand since the areas are either located in or near the sandy soils. The A_2 horizon, which varies from 9 to 10 inches in thickness, is a brownish gray or yellowish gray to a gray or almost white silt loam. The gray layer passes abruptly into the B horizon. The latter is a compact, strongly mottled, yellowish gray clay, containing many red iron concretions. This stratum is highly impervious to the penetration of water. At

about 28 inches in depth, the C horizon occurs. It is a friable, mottled, drab-bish yellow or yellow silt loam.

Management.—Most of the areas of Brown-Gray Silt Loam On Tight Clay are medium acid in reaction and require an application of about 3 tons of limestone an acre to grow sweet clover. It is well to determine the need for limestone before deciding to make an application on this type, unless it is known definitely that limestone is needed, for there are some areas that contain sufficient lime material. Help can be secured from the farm adviser or from the Agricultural Experiment Station in this matter. In addition to taking care of the need for limestone, the growing and turning down of leguminous crops, and provision for the removal of excess water by surface drainage should be given consideration in the management of this soil.

Brown-Gray Sandy Loam On Tight Clay (768)

Brown-Gray Sandy Loam On Tight Clay, Upland, occupies slightly less than four square miles. In topography and drainage it is similar to Brown-Gray Silt Loam On Tight Clay.

The A_1 horizon, which has an average depth of about 8 inches, is a grayish brown sandy loam. The A_2 horizon, extending to about 20 inches in depth, is a yellowish gray to gray sandy loam. This horizon passes abruptly into the B horizon, which is a highly impervious, plastic, compact, gray sandy clay stratum containing many red iron concretions. The thickness of this layer varies from 8 to 10 inches. The material underlying this compact layer varies from a gray sand to a yellow sand streaked with some gray clayey sand.

Management.—For suggestions regarding the management of this type, the reader is referred to the discussion of the preceding type, Brown-Gray Silt Loam On Tight Clay (728).

Black Silt Loam (725, 925, 1125)

Black Silt Loam, as it occurs in the upland, is closely associated with Brown Silt Loam, and usually occupies the depressions and the low areas along small streams and draws. The topography is flat and the natural drainage is not well established. The areas of this type are small but are well distributed over the upland. The type comprizes in total 30.14 square miles, or more than 4 percent of the area of the county.

The A_1 horizon, which averages about 7 inches in thickness, is a black silt loam. The A_2 horizon, which extends to about 16 or 17 inches in depth, varies from a black silty clay loam to a plastic, drab clay loam. The B horizon is a plastic, fairly compact, mottled, black clay loam which gradually changes into a plastic, drab to yellowish drab, clay loam in the lower part.

Management.—Black Silt Loam is a rich soil, well supplied with lime and suited to the growth of any of the general farm crops. Portions of the type are so poorly drained that they are not farmed and even where regular cropping is carried on, the underdrainage frequently needs improvement. Provi-

sion must be made for adding fresh organic matter, even tho this soil has a high organic-carbon content. No fertilizer treatment is advised at the present time.

Dune Sand (781, 981)

Dune Sand, Upland, occurs principally in the sandy areas bordering the swamps and terraces. Its total area in the county includes a little over 8 square miles. Its presence in the upland is due to wind action upon the sandy material, blowing it into ridges. The sand dunes are scattered over most of the sandy area and vary from a few feet to 60 or 75 feet in height above the adjacent plain. Wind erosion has formed blowouts in many of these sand dunes, some of which cover a large portion of the surface of the dune. The topography varies from billowy to rolling.

The A_1 horizon, which is about 2 or 3 inches in depth where there has been some accumulation of organic matter, is a brown loamy sand. There is no horizon development below the thin A_1 or surface horizon, the material being incoherent yellow sand.

Management.—Since there is very little organic matter in the sand, this must be increased by the growth of legumes before other crops can be satisfactorily grown. An application of limestone should be made to insure a catch of legumes. Reforestation also aids the abeyance of wind erosion. The reader is referred to page 62, where the results from the Oquawka experiment field will be found, for further suggestions regarding the management of this type.

Gravelly Loam (790)

Gravelly Loam is an unimportant type appearing in the morainal areas in the southeastern part of the county. It represents the gravel outcrops on the crests of the moraine. It has very little agricultural value. Some of the gravel, altho not of good quality, is being used for road building. This type should be kept in permanent pasture or it may be used for small fruit production when conveniently situated for this purpose.

UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along streams and on or near somewhat steep morainal slopes. They are characterized by a yellowish gray color, which is due to their low organic-matter content. The deficiency of organic matter has been caused by the long-continued growth of forest trees. After the forests invaded the prairies, two effects were produced: the shade of the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large organic content in prairie soils; and the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed completely or were burned by forest fires. Furthermore, the organic matter that had been produced by the prairie grasses became gradually dissipated during the occupation of the land by the trees. As a result the organic-matter content of the upland timber soils has been reduced until it is decidedly lower than that of the adjacent prairie land. Several generations of

trees were necessary to produce the present condition of the soil. The upland timber soils of Lee county occupy 5.44 percent of the area of the county.

Yellow-Gray Silt Loam (734, 934, 1134)

Yellow-Gray Silt Loam occupies 25.31 square miles, or 3.49 percent of the area of the county. It occurs as light-colored soil near the streams, most of it being situated along Rock river and its tributaries. Several isolated areas occur on the moraine in the southeast part of the county. The topography of the type varies from undulating to rolling. The natural drainage of this type is, in the main, good.

The A_1 horizon, which is about 6 inches in depth, is a brownish yellow to a grayish yellow silt loam. The A_2 horizon is about 10 or 11 inches in thickness. It is a mottled yellow silt loam. The B horizon, which is about 12 inches thick, is a slightly mottled, slightly plastic, compact, yellow silt loam. The C horizon is a friable, yellow silt loam, mottled with gray, and contains many reddish brown iron concretions.

Management.—Yellow-Gray Silt Loam is now used rather extensively for pasture, particularly the rolling portions of the type. In the morainic portion of the type the slopes which have been sufficiently eroded show the presence of carbonates. This condition can be taken advantage of for growing legumes without limestone. On the more nearly flat areas no carbonates occur within 40 inches of the surface and limestone must be used for alfalfa or sweet clover and usually for red clover.

This soil is low in organic matter and for this reason runs together and packs badly with heavy rains. This difficulty can be gradually overcome by providing for the return of organic matter, preferably legumes, at frequent intervals. The portions of this type which are topographically suitable for regular cropping are productive when good farming methods are practiced. In addition to the use of limestone and legumes, as above suggested, it is advised that a thoro trial be made of both rock and acid phosphate. The most approved method of using rock phosphate is well known. Acid phosphate should be applied for wheat after plowing and before working down the seed bed, at the rate of about 300 pounds an acre. No definite statements are made as to which of these phosphates is likely to prove superior on Yellow-Gray Silt Loam because there is no experiment field located on this type, as it occurs in Lee county, from which conclusions may be drawn.

Yellow Silt Loam (735, 935, 1135)

Yellow Silt Loam occurs as hilly and eroded land in the form of an inner timber belt adjacent to streams, and also on other slopes where erosion has gone on for a considerable period of time. It occupies only a small part of the area of the county, the total area of the type being less than four and a half square miles.

The A_1 horizon, which varies from 0 to 3 inches in thickness, depending on the rate of erosion, is a brownish yellow to yellow silt loam. Erosion has re-

moved most of the upper horizons, and the B horizon, or subsoil, occurs either immediately at the surface or just below it. It is a slightly plastic, compact, silty clay, golden yellow in color.

Management.—The most difficult problem in the management of Yellow Silt Loam is to control general surface washing and gullying. If the land is cropped at all, a rotation should be adopted which provides for some sort of vegetation on the ground as much of the time as is possible, and for a minimum of cultivated crops. When the land is tilled, care must be taken in plowing and cultivating the slopes not to encourage the starting of gullies. Every effort should be made to maintain and increase the organic-matter content of the soil. It would be well to reforest some of the areas near the river and thus stop the continual erosion by that method. An application of limestone for growing legumes is recommended.

Yellow-Gray Sandy Loam (764, 964)

Yellow-Gray Sandy Loam occurs in the northern part of the county and in the sandy areas adjacent to the swamp region. It covers 6.83 square miles, or a little less than 1 percent of the area of the county. Its topography varies from undulating to rolling. Drainage is fairly good in most of the areas.

The A_1 horizon, which is about 5 inches in depth, is a grayish yellow sandy loam. The A_2 horizon, extending to about 17 inches in depth, is a yellow sandy loam. The B horizon is a slightly compact, yellow, sandy clay loam. Below 30 inches a coarse-grained, yellow, sandy silt loam occurs, frequently passing into glacial till of a gravelly textured material at 36 to 38 inches below the surface.

Management.—The management requirements of this type are practically the same as for Yellow-Gray Silt Loam. An application of limestone at the rate of 2 to 3 tons an acre is recommended for the growing of legumes. Wind erosion is somewhat troublesome on this soil and special methods should be used to control it, such as keeping vegetation on the land during as large a portion of the year as possible and using tillage methods which leave the surface somewhat rough.

Yellow Sandy Loam (765)

Yellow Sandy Loam occupies only .76 square mile, or .14 percent of the area of the county. It is found in the region of the outcrops of St. Peter's sandstone along Rock river. The topography of the type is rolling, with some rather short steep slopes.

The A_1 horizon varies in thickness from 0 to 3 inches, depending on the amount of accumulation of organic matter, and is a grayish yellow sandy loam. The A_2 horizon, extending to about 15 inches in depth, is a yellow sandy loam. The B horizon, which is about 8 inches thick, is a slightly compact, yellow, sandy, silt loam. The C horizon is a reddish yellow, sandy clay loam becoming a fairly sticky, residual sandy clay just above the sandstone. The depth to the sandstone varies from 25 to 45 inches.

Management.—This type should be devoted exclusively to timber. It is now generally bearing a fair growth of jack oak, red oak, and hickory.

Yellow-Gray Silt Loam On Limestone (734.5)

Yellow-Gray Silt Loam On Limestone is one of the minor types in Lee county. It comprizes only 358 acres and occurs as isolated areas in the northwestern part of the county. It is undulating in topography. If the limestone is near the surface, the areas are practically non-agricultural, except for pasture. This type changes abruptly into the eroded Yellow Silt Loam On Limestone. Often upon breaking up the soil, dark spots appear on the surface. These spots occur where the underlying limestone is sufficiently near the surface to keep the surface soil supplied with carbonates, thus retaining the dark-colored organic compounds.

The A_1 horizon, which is about 5 inches in depth, is a grayish yellow silt loam. The A_2 horizon, extending to 18 inches in depth, is a yellow silt loam. The B horizon is a compact, yellow silt loam, becoming slightly reddish just above the limestone. Often a heavy, red, residual clay, 2 to 3 inches in thickness, occurs directly above the rock. The average depth to the limestone rock is 22 to 24 inches.

Management.—Much of this type is best suited for pasture because of the nearness of the limestone to the surface. The areas which are suitable for cultivation require the same management as that advised for Yellow-Gray Silt Loam with the exception that less limestone is required.

Yellow Silt Loam On Limestone (735.5)

Yellow Silt Loam On Limestone occupies only 1.43 square miles, or 915 acres. It is found in the northwestern part of the county where erosion has removed most of the surface soil.

The A_1 horizon is a brownish yellow to grayish yellow silt loam, averaging about 3 or 4 inches in depth, depending upon the depth of accumulated organic matter. The A_2 horizon, which is about 10 inches in thickness, is a yellow silt loam. The B horizon is a plastic, compact, yellow silt loam, mottled with gray and containing many red iron concretions. The depth to the underlying limestone varies from 8 to 30 inches.

Management.—This type is, very largely, suitable only for pasture or timber.

TERRACE SOILS

Terrace soils are formed on terraces or old fills. The terraces owe their formation to the deposition of material of overloaded streams which became greatly enlarged and flooded the valleys during the melting of the glaciers. Sometimes these valleys were filled almost to the level of the upland. Later the streams cut down thru the fills and developed new bottom lands. The lowest and most recently formed bottom land is called first bottom. The higher land, no longer flooded, or very rarely so, is designated as second bottom, or terrace.

Brown Silt Loam Over Gravel (1527)

Brown Silt Loam Over Gravel is one of the most widely distributed terrace types in Lee county. The largest areas of the type occur in the Inlet swamp region in the northeastern part of the county. It occupies 52.51 square miles, or 7.26 percent of the area of the county. The areas of the type which occur in the Green river basin contain an appreciable amount of sand. The topography of the type is flat to undulating. Drainage is well established.

The A_1 horizon, which is about 8 inches in depth, is a light brown to brown silt loam. The A_2 horizon, extending to about 18 inches in depth, is a yellowish brown silt loam. The B horizon, which is about 14 inches thick, varies from a friable, yellow silt loam to a slightly plastic, yellow, silty clay loam with slight mottling. Below 32 inches, the material varies from a friable, yellow, sandy silt loam to a sandy loam with terrace gravel and sand occurring from 38 to 45 inches below the surface.

Management.—Brown Silt Loam Over Gravel shows considerable variation in lime requirement. For this reason it is advised that the assistance of the farm adviser or the Experiment Station be secured in determining whether any limestone is needed, and if so, how much. The reader is referred to the discussion of the management of Brown Silt Loam, Upland, (page 16) for further suggestions regarding the management of this terrace type.

Black Silt Loam (1525)

Black Silt Loam, Terrace, occupies 54.89 square miles, or 7.58 percent of the area of the county. It is closely associated with Brown Silt Loam, Terrace, but occupies lower-lying areas. In the southwestern part of the county the type is more or less sandy in texture, owing to the wind blowing some of the sandy material upon the silty areas. The topography is flat.

The A_1 horizon, which is about 6 inches thick, is a black silt loam. The A_2 horizon, extending to about 18 inches in depth, is a plastic, black clay loam or silty clay loam. The B horizon, which is 10 to 12 inches in thickness, is a plastic, slightly compact, drabbish black to black clay loam, with an appreciable amount of sand present in the areas that occur in the western part of the county. The C horizon varies from a partially friable, yellow, silty clay loam to a drab clay loam, containing yellow and red iron concretions.

Management.—Black Silt Loam, Terrace, is rich in organic matter, much of which, however, is probably resistant to decay because it is in an advanced stage of decomposition. The chief requirements in the management of this type are the improvement of the underdrainage and the control of the harmful effects of the alkaline condition associated with poor drainage.

The installation of good underdrainage may be expected to decrease gradually the amount of alkali in the soil, tho the decrease to a point where there is no longer alkali toxicity is slow. Treatment with potash salts, either potassium sulfate, or potassium chlorid, at the rate of about 100 pounds an acre, will counteract the bad effects of the alkali. Straw and strawy manure are also good materials to apply to alkali soils. This soil produces good alfalfa and sweet clover.

Black Sandy Loam (1561)

Black Sandy Loam occurs fairly well distributed thruout the swamp area of Lee county and covers an area of 34.37 square miles, or 4.75 percent of the area of the county. Its topography is flat. This type was developed under conditions of poor drainage.

The A_1 horizon, which is about 10 to 12 inches in depth, is predominantly a black sandy loam. It varies in texture from a peaty loam to a sandy loam. The A_2 horizon extends to about 30 inches in depth and it ranges from a black sandy loam to black sand. The B horizon is a slightly compact, drabbish yellow, clay loam or sandy clay loam containing red iron concretions.

Management.—Black Sandy Loam, Terrace, as it occurs in Lee county, is very generally alkaline and in need of better drainage. Much has already been done in improving the drainage conditions. In laying tile in this soil, great care must be used in making the joints as the fine sand particles, many of which are rounded, cause trouble by clogging the drains. For further suggestions regarding the management of this type, the reader is referred to the recommendations made for Black Silt Loam, Terrace, page 24.

Brown Sandy Loam Over Gravel (1566)

Brown Sandy Loam Over Gravel is one of the predominating soil types of the Green river basin. It occupies 30.12 square miles, or 4.16 percent of the area of the county. Its topography varies from undulating to slightly rolling, the rolling topography being represented by the sand dunes. The areas are slightly higher than the adjacent Black Sandy Loam.

The A_1 horizon, which is about 8 inches in depth, is a brown sandy loam. The A_2 horizon, extending to about 20 inches in depth, is a brownish yellow to yellow sandy loam. The B horizon is a medium to coarse-grained yellow sandy loam. Very little sandy gravel occurs within 60 inches of the surface.

Management.—Brown Sandy Loam Over Gravel, as it is mapped, shows considerable variation both in character of the soil and in productivity. The better portions of the type are productive when well farmed and present no unusual problems of management. The poorer areas are very sandy and are subject to drouth and to drifting by the wind. The drainage of this type has been fairly well taken care of by open ditches and tile.

No very specific recommendation can be made for the use of limestone because of the great variability in lime requirement. The higher, coarser-textured areas are uniformly acid and need 2 to 3 tons of limestone an acre to grow alfalfa or sweet clover. These higher areas are in particular need of nitrogenous organic matter and will grow good corn following the turning down of a green-manure crop of sweet clover in the spring. Alfalfa may be grown successfully on this land, tho particular care must be used in getting a stand.

Black Clay Loam (1520)

Black Clay Loam occurs in the Inlet swamp in the eastern part of the county and occupies 1.52 square miles. It is flat in topography and is on the same level as the Black Silt Loam. The transition between these two types is gradual.

The A_1 horizon, which is about 6 inches in depth, is a black clay loam. The A_2 horizon, extending to 12 inches in depth, is a heavy, plastic, black clay loam, gradually changing into a plastic, slightly compact, drab clay loam subsoil which extends to about 22 inches in depth. The B horizon is a plastic, drab clay loam splotched with yellow streaks and containing numerous red iron concretions.

Management.—Black Clay Loam, Terrace, is a productive soil, does not need limestone, and rarely shows an alkaline condition. It requires only good farming, including some improvement in underdrainage and regular additions of nitrogenous organic matter, to produce good crops.

Yellow-Gray Silt Loam Over Gravel (1536)

Yellow-Gray Silt Loam Over Gravel is found along Rock river. It occupies only 2.45 square miles, or .33 percent of the area of the county. Its topography is slightly undulating. The natural drainage of the type is good, owing to the gravelly and sandy subsoil.

The A_1 horizon, which is about 6 inches in depth, varies from a grayish yellow to a brownish yellow silt loam. The A_2 horizon, extending to about 18 inches in depth, is a grayish yellow silt loam, becoming strongly mottled below 12 inches. The B horizon, which is about 10 inches thick, is a compact, strongly mottled, yellow silt loam. It rests on a yellowish gray sandy loam with some fine gravel occurring 40 to 50 inches below the surface.

Management.—Yellow-Gray Silt Loam Over Gravel is well drained and productive if well farmed. It is somewhat acid and is low in nitrogen and organic matter. About 2 tons of limestone an acre will permit the growth of sweet clover and alfalfa. It is an excellent alfalfa soil, and if this crop is grown, it is suggested that an application of ½ to 1 ton an acre of rock phosphate, or 500 pounds of acid phosphate, be made and well worked into the soil at the time of seeding.

Yellow-Gray Sandy Loam Over Gravel (1567)

Yellow-Gray Sandy Loam Over Gravel occurs in small areas along Rock river and in the Green river terrace southwest of Amboy. It covers an area of 2.33 square miles, or .32 percent of the area of the county. In topography it varies from undulating to rolling, owing in part to the presence of sand dunes.

The A_1 horizon is about 4 or 5 inches in depth and is a grayish yellow sandy loam. The A_2 horizon, which is about 12 inches in thickness, is a slightly mottled, yellow sandy loam. The B horizon, which is 6 or 7 inches thick, is a slightly compact, slightly mottled, yellow, clayey sandy loam. Below this depth yellow sand occurs.

Management.—Yellow-Gray Sandy Loam Over Gravel is a less productive soil than Yellow-Gray Silt Loam Over Gravel. It needs the same treatment as suggested for the latter type with particular attention being given to its nitrogen and organic-matter deficiencies.

Brown-Gray Silt Loam On Tight Clay (1528)

Brown-Gray Silt Loam On Tight Clay, Terrace, occurs in small areas thruout the terraces of both the Green river basin and Inlet swamp. It occupies only .59 square mile in the county. Often these areas are of a more or less sandy texture, owing to the close association with sandy soils. The topography is flat and the natural drainage is poor.

The A_1 horizon, to a depth of 6 inches, is a grayish brown to brown silt loam, with an appreciable amount of sand. The A_2 horizon is a stratum of gray silt extending to 20 inches in depth. The B horizon, which is about 10 inches in thickness, is a highly plastic, compact, tight clay, yellowish gray to gray in color. Below 30 inches a gray to drabbish gray clay loam occurs. This is plastic but not tight.

Management.—Brown-Gray Silt Loam On Tight Clay, Terrace, has the same management requirements as the corresponding upland type to which the reader is referred for suggestions, page 18.

Brown-Gray Sandy Loam On Tight Clay (1568)

Brown-Gray Sandy Loam On Tight Clay, Terrace, occurs as scattering areas in the Green river swamp, usually in connection with the sand dunes. It occupies 3.31 square miles, or .46 percent of the area of the county. Its topography is flat and its natural drainage is poor. Seepage waters from the sand dunes keep some of the areas well saturated.

The A_1 horizon, which is 4 to 8 inches in depth, is a brown sandy loam with a gray cast, particularly after it dries following a rain. The A_2 horizon, which is about 10 inches in thickness, is a yellowish gray to gray sandy loam. The B horizon, which is 6 or 8 inches in thickness, is a gray, sandy, highly impervious clay. Below this depth yellowish gray sand occurs.

Management.—Brown-Gray Sandy Loam On Tight Clay is strongly acid, requiring 3 to 4 tons of limestone an acre. Otherwise its management requirements are the same as those for the corresponding upland type, suggestions for which are found on page 19.

Dune Sand (1581)

Dune Sand, Terrace, is widely distributed thruout the Green river swamp and Inlet swamp. The dunes vary from 2 or 3 feet to 50 or 60 feet in height. They cover all told, 7.45 square miles, or 1.03 percent of the area of the county. The topography varies from billowy to rolling.

The A_1 horizon is a brownish yellow, loamy sand where there has been a little organic-matter accumulation. At a depth of 3 or 4 inches this changes into a yellow sand which extends to a considerable depth below 40 inches.

Management.—The management of Dune Sand, Terrace, differs in no essential from the management of Dune Sand, Upland. A discussion of the management of the latter type will be found on page 20.

Gray Sandy Loam (1562)

Gray Sandy Loam occupies 173 acres in Lee county and is located in the northwest corner of Reynolds township, Township 39 North, Range 1 East. The area is so situated that it receives much seepage water. This fact probably accounts for the formation of this type.

The A_1 horizon, which is about 6 inches in depth, is a brownish gray to yellowish gray sandy loam. The A_2 horizon, extending to a depth of about 14 inches, is a yellowish gray to gray sandy loam. The B horizon is a compact, impervious, sandy clay loam subsoil, varying from yellowish gray to yellow in color. Below an average depth of 32 inches a yellow sand occurs which is usually water logged even during the periods of drouth.

Management.—Gray Sandy Loam, Terrace, fortunately occupies a very small area in Lee county. Its management is the same as that required for Brown-Gray Silt Loam On Tight Clay, see page 19.

LATE SWAMP AND BOTTOM-LAND SOILS

In the group designated as Swamp and Bottom-Land Soils are included the bottom lands or flood plains along streams, the swamps, the poorly drained lowlands, and peats and mucks, whether on upland or terraces. Much of the soil is of alluvial formation and is subject to overflow.

Black Mixed Loam (1450)

Black Mixed Loam occurs as low swampy areas along streams and the poorly drained depressions in the uplands and terraces. It occupies a total area of 25.27 square miles.

The A_1 horizon varies from 7 to 8 inches in depth. It is brown to black in color and varies in texture from sandy loam to silt loam. Below this depth the color becomes drabbish black or drab, with the proportion of drab becoming greater with increasing depth. Considerable variation occurs in the texture of both the subsurface and the subsoil.

Management.—Black Mixed Loam is a productive soil when well drained; however, drainage is so poor over much of the type that it is left in pasture and meadow. The chief difficulty in draining this land is in getting outlets.

Mixed Loam (1454)

Mixed Loam occurs as first bottom along Rock river, Green river, and several small streams in the county. It occupies 18.93 square miles, or 2.62 percent of the area of the county. This type cannot be adequately described because of its variations. It is mapped as Mixed Loam because it is made up of a mixture of several types which occur in areas too small to be mapped separately.

The surface varies in color from brown to yellowish gray and in texture from a silt loam to a clay loam. The material below the 8- or 9-inch surface horizon also varies in texture, but usually has a yellowish gray color.

Management.—Mixed Loam is subject to overflow and the deposition of new material maintains a supply of the elements of plant food. Good farming is the only requirement in the management of this type.

Deep Peat (1401)

Deep Peat is found in scattering areas thruout the swamp and upland, totaling 2.57 square miles. The largest area is located in Sections 1 and 12, Township 37 North, Range 2 East.

The soil is a brown to black, well-decomposed peat to a depth of several feet, with the exception that near the borders of the areas a clay to sandy clay subsoil occurs from 35 to 40 inches below the surface.

Management.—The Deep Peat in Lee county is, for the most part, not sufficiently alkaline to injure crops. Drainage has been provided in most of the areas by means of open ditches. It is advisable to apply about 100 pounds per acre of one of the potash salts for corn.

Medium Peat On Clay (1402)

Medium Peat On Clay is found in a few small scattered areas thruout the county. The largest area is located in Wyoming township (Section 12, Township 37 North, Range 2 East). This area covers about 96 acres. It is fairly well drained and the depth to clay is fairly uniform over the area. The soil is about the same in texture and color as the Deep Peat with the exception that at 18 to 20 inches in depth the drab clay subsoil occurs and extends to below the 40-inch depth. This type requires the same management as Deep Peat.

RESIDUAL SOILS

Residual soils are formed from the residue left in place thru the weathering of the bed rock and the accumulation of organic matter. These soils are found along Rock river and its tributaries. A few isolated areas are found in the vicinity of Ashton and Lee Center. The residual soils are formed from both limestone and sandstone.

Sand (083)

Residual Sand occurs in the vicinity of Grand de Tour, where a fold in the underlying rock has occurred and caused the sandstone to outcrop. This fold is known as the LaSalle anticline. Thru weathering, the sandstone has disintegrated into a white sand which supports very little vegetative growth. No soil horizons have been developed. Often broken pieces of sandstone are found mixed with the sand. This formation is non-agricultural in value. Very little pasture is obtainable on it for grazing purposes.

Sandstone Outcrop (099)

Sandstone Outcrop occurs along the Rock river bluffs, in the vicinity of Grand de Tour, where the river makes its picturesque bend. It is non-agri-

cultural, and the only value of the formation lies in its scenic beauty. The type occupies an area of 38 acres in the county.

Stony Loam (098)

Stony Loam occurs on the slopes of the eroded areas in the northern part of the county. Stones ranging up to 8 or 10 inches in diameter are numerous enough to interfere with cultivation. This type occupies only .15 square mile, or .02 percent of the county. It is of little agricultural value.

Limestone Outcrop (099)

Limestone Outcrop is found in abundance along Rock river and its small tributaries. Most of the outcrops occur as vertical exposures varying from 5 or 6 feet to 60 or 70 feet in thickness. There are no shipping quarries in Lee county. There are, however, numerous quarry sites in the northwestern and north-central parts of the county. Many of these outcrops are suitable for development as a source of agricultural limestone. Information regarding position, character, and composition of these outcrops may be secured from the State Geological Survey, Urbana, or from the Agricultural Experiment Station.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items, such as native vegetation (whether timber or prairie), topography, and geological origin and formation, may assist in the differentiation of types, altho they are not fundamental to it.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a matured soil, three horizons designated as A, B, and C are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the A horizon.

C designates the layer lying below the B horizon and in which the material has been less affected by the weathering processes.

Frequently differences within these strata or zones are discernible, in which case they are subdivided and described under such designations as A_1, and A_2, B_1, and B_2, etc.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in differentiating soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of this Report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state

800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* formed by material derived from the Illinoisan or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged Glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data beginning on page 7.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, crop-

ping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain...	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw...	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain....	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover....	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs.....	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.....	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oats straw.....	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed....	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay....	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed ..	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay...	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay....	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface $6\frac{2}{3}$ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached	.....	10	100

[1] See footnote to Table 5

[2] Young second-year growth ready to plow under as green manure.

[3] Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning

recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4_1 have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.

1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, acid phosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate, and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as

sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average livestock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached

out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of

crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before

the crop is planted. Whether the crop be corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the better adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to those Occurring in Lee County)

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system stable manure is used to furnished organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system. Some modifications have been introduced in recent years.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manues, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grain to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated (aP = acid phosphate, bP = bonemeal, rP = rock phosphate, sP = slag phosphate)
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
Le = Legume used as green manure
Cv = Cover crop
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed
| = Heavy vertical rule, indicating the beginning of complete treatment
|| = Double vertical rule, indicating a radical change in the cropping system

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

THE DIXON FIELD

A University soil experiment field located in Lee county has been in operation for the past 16 years. This field lies about two miles west of Dixon on land characteristic of the region. While the soil is mainly Brown Silt Loam, a detailed examination has revealed the presence of three other distinguishable types designated as Brown Silt Loam On Clay, Light Brown Silt Loam, and Brown Silt Loam, deep phase, which are scattered in spots over the field, as shown in the accompanying diagram (Fig. 2). There are also charted on this diagram

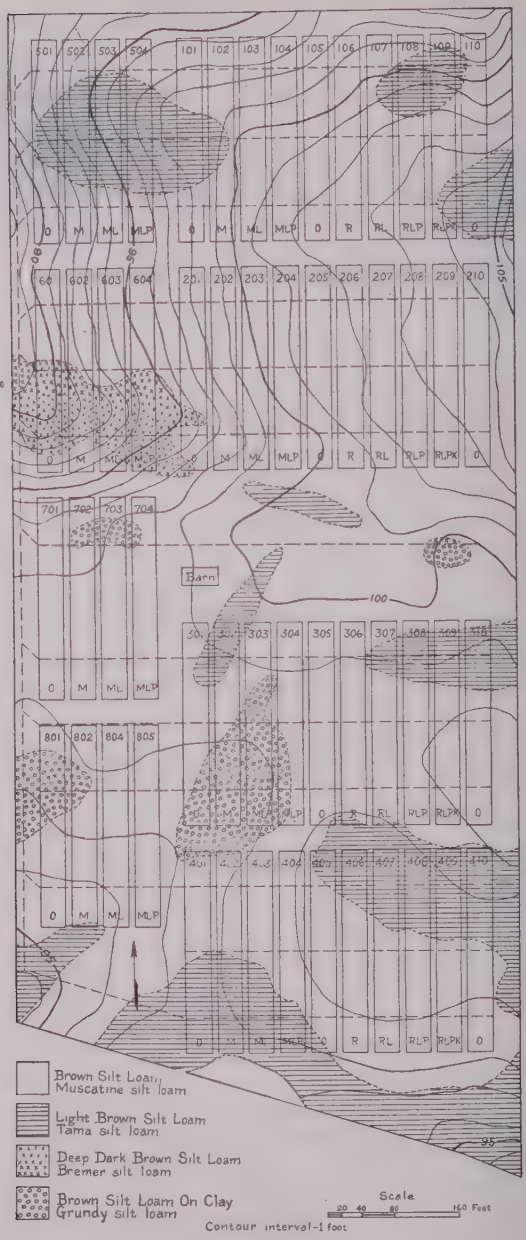


FIG. 2.—DIAGRAM OF THE DIXON SOIL EXPERIMENT FIELD

This diagram shows the arrangement of plots, the soil treatments applied, the location of the different soil types, and by means of contour lines, the natural drainage of this field.

the arrangement of plots with their respective treatments, and the topography of the land as represented by contour lines. As these lines indicate, the land is rolling, with rather steep slopes in the northern portion of the field. A thoro system of tiling has been installed and the drainage is good.

The field, which includes about 21 acres, is laid out into two general systems of plots, each system being made up of four series.

The 100, 200, 300, and 400 Series

The four series of plots designated as the 100, 200, 300, and 400 series are each made up of 10 fifth-acre plots under the different soil treatments indicated in the accompanying tables and diagram. A rotation system of wheat, corn, oats, and clover has been practiced. The crops were managed practically as described for the general plan on page 49 until 1921, when for a period of four years both the first and second crops of clover were removed as hay. At this time the practice of returning the oat straw to the land was discontinued and the following year the return of the wheat straw was likewise discontinued. In 1922 the applications of limestone were indefinitely suspended, the plots having received a total of 7½ to 9 tons an acre on the different series. In 1923 the phosphate applications were evened up to 4 tons an acre, and no more will be applied for an indefinite period.

Since the Dixon field is located in Lee county, a complete record of the yields of all crops grown is included in this Report. The results for the series under discussion are given in Table 7. These results are summarized in Table 8 to show the average annual yields for the different kinds of crops, including the years since the complete soil treatment on the respective plots has been in effect.

In looking over these results, one may observe first the extremely beneficial effect of farm manure. The crop increase due to manure used alone amounts to nearly 20 bushels an acre for corn, about 12 bushels for oats, almost 7 bushels for wheat, over two-thirds of a ton for clover, and one-third of a ton for soybean hay.

Organic manure furnished by residues has likewise proved consistently beneficial, altho not in the same degree as stable manure.

FIG. 3.—WHEAT ON THE DIXON FIELD

Under the treatment shown at the right the eleven-year average yield of wheat has been 32.9 bushels an acre, while the corresponding check plot has produced 21.7 bushels.

TABLE 7.—DIXON FIELD, SERIES 100, 200, 300, 400
Annual Crop Yields, 1910-1926—Bushels or (tons) per acre

Plot No	Soil treatment applied	1910 Barley[1]	1911 Corn[3]	1912 Oats[5]	1913 Clover[5]	1914 Wheat[7]	1915 Corn	1916 Oats	1917 Soybeans	1918 Barley[8]	1919 Corn	1920 Oats	1921 Clover	1922 Wheat	1923 Corn	1924 Oats	1925 Clover	1926 Wheat
101	0	20.5	56.4	35.2	(3.14)	24.8	5.6	72.0	(1.62)	43.3	35.9	42.8	(1.11)	20.0	40.6	42.2	(2.29)	38.0
102	M	20.8	62.8	39.8	(3.32)	25.3	32.9	70.8	(1.82)	46.4	50.0	64.2	(1.59)	28.5	56.0	57.2	(2.34)	41.7
103	ML	24.4	60.5	47.2	(3.47)	26.6	38.1	79.2	(2.25)	55.2	60.7	76.2	(1.88)	33.3	63.8	67.2	(2.25)	45.8
104	MLP	24.7	64.7	42.2	(3.56)	33.5	41.7	81.6	(2.40)	58.3	70.6	86.6	(1.89)	38.2	62.0	71.6	(2.30)	48.2
105	0	26.8	64.3	47.8	1.00	32.8	18.5	76.6	10.8	49.5	44.8	52.3	(1.11)	26.8	42.0	45.9	(2.10)	32.0
106	R	24.9	65.9	50.0	1.25	37.7	24.4	78.8	9.1	53.8	42.5	66.9	(1.65)	26.0	53.6	60.3	(1.02)	40.3
107	RL	24.4	67.5	49.5	1.00	34.2	29.0	81.2	10.8	54.5	66.5	77.7	(1.90)	29.4	60.9	79.7	(1.21)	43.5
108	RLP	22.3	68.2	44.5	1.00	37.9	33.0	83.4	11.0	59.0	71.4	87.2	(2.36)	35.5	58.0	78.4	(1.64)	45.8
109	RLPK	20.8	69.2	49.4	.75	35.2	32.6	78.1	10.3	56.9	70.9	83.9	(2.80)	37.5	56.1	69.7	(1.80)	44.3
110	0	21.6	65.0	43.3	(2.96)	24.9	2.4	69.7	(1.28)	45.4	45.9	55.6	(1.24)	23.3	42.6	41.3	(2.13)	28.3
		Clover[1]	Wheat[4]	Corn	Oats	Clover	Wheat	Corn	Oats	Soybeans	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats	Clover[9]
201	0	(1.69)	31.9	3.3[6]	49.2	(1.76)	27.9	37.8	68.4	(1.80)	23.8	30.6	31.6	(2.13)	9.4	41.6	45.0	(.74)
202	M	(1.56)	31.0	12.9[6]	55.6	(2.13)	28.2	44.5	82.3	(1.80)	26.3	42.9	41.9	(2.98)	19.9	57.6	60.6	(1.84)
203	ML	(1.54)	33.8	11.4[6]	52.7	(2.54)	29.2	49.5	85.6	(1.85)	31.2	48.3	39.2	(3.31)	21.6	62.4	75.3	(2.15)
204	MLP	(1.87)	37.4	26.2[6]	58.4	(2.77)	34.0	52.8	93.0	(1.96)	37.3	54.2	44.5	(3.43)	25.3	62.0	70.0	(2.20)
205	0	(1.87)	30.5	21.1	58.9	(1.83)	28.0	43.4	76.1	14.6	27.8	44.2	31.4	(2.59)	10.3	45.0	50.3	(.87)
206	R	.....[2]	37.9	37.5	58.4	1.42	31.3	44.3	77.7	17.1	28.9	46.9	35.8	(3.05)	13.7	51.8	52.2	(1.02)
207	RL	.....[2]	30.7	34.2	52.7	1.58	30.0	48.5	77.7	16.2	28.8	53.6	31.7	(3.24)	16.8	57.2	55.9	(1.58)
208	RLP	.....[2]	41.0	42.2	58.6	2.17	36.8	50.4	85.9	13.3	35.2	52.3	39.2	(3.65)	20.8	59.6	71.9	(2.26)
209	RLPK	..... [2]	41.6	61.5	56.1	2.00	34.6	49.4	84.4	15.0	36.4	55.2	44.7	(4.02)	24.0	62.2	76.3	(2.28)
210	0	(1.80)	30.6	20.4	52.3	1.17	25.1	40.9	68.1	(1.94)	28.2	39.0	36.4	(2.40)	13.6	45.8	45.9	(.70)

[1]No soil treatment. [2]No seed harvested. [3]Residues only. [4]No manure or lime. [5]Residues and lime only. [6]Corn damaged by white grubs. [7]No manure. [8]Wheat winterkilled; barley grown as a substitute crop. [9]On account of damage by insects, only one crop of clover was secured.

TABLE 7.—DIXON FIELD, SERIES 100, 200, 300, 400—*Concluded*

Plot No.	Soil treatment applied	1910 Oats[1]	1911 Soybeans[2]	1912 Barley[3,4]	1913 Corn	1914 Oats	1915 Clover	1916 Wheat	1917 Corn	1918 Oats	1919 Soybeans	1920 Wheat	1921 Corn	1922 Oats	1923 Clover	1924 Wheat	1925 Corn	1926 Oats
301	0	50.0	14.5	17.2	35.5	54.7	(1.35)	7.2	24.9	76.6	(1.25)	19.1	47.9	49.4	(.73)	20.0	55.8	22.8
302	M	56.9	12.8	30.6	56.6	60.6	(3.38)	9.2	55.3	91.4	(1.90)	30.8	71.3	79.7	(1.97)	33.0	85.0	40.3
303	ML	57.3	16.7	27.0	60.4	61.1	(3.41)	11.6	57.2	89.1	(1.90)	33.2	78.8	86.1	(2.32)	41.2	87.6	50.6
304	MLP	54.5	16.0	32.5	55.3	60.6	(3.57)	18.2	60.7	91.2	(1.78)	36.9	77.0	88.8	(2.27)	38.2	92.6	45.0
305	0	56.1	17.9	27.6	42.5	60.0	.42	12.2	26.6	82.5	9.4	18.3	54.6	62.5	(1.17)	26.2	63.0	26.9
306	R	56.7	15.3	37.7	47.5	59.8	.58	16.2	40.6	85.9	13.8	18.7	60.7	69.5	(1.46)	27.3	64.0	34.1
307	RL	48.9	18.1	31.2	48.3	56.2	.58	14.9	38.7	85.8	13.4	20.7	70.8	81.3	(1.83)	35.5	79.6	43.8
308	RLP	49.5	17.9	37.5	49.2	54.2	.50	21.1	45.5	78.1	13.6	26.4	70.8	80.2	(1.63)	41.3	81.0	43.8
309	RLPK	51.6	19.1	40.6	53.4	58.0	.42	22.1	46.4	76.6	14.2	27.9	75.1	87.5	(2.04)	37.7	81.2	48.8
310	0	48.1	15.4	27.8	44.4	58.8	(2.50)	10.6	29.4	81.4	(1.30)	13.2	49.3	57.7	(.79)	20.0	66.4	24.7
		Corn[1]	Oats[2]	Soybeans[5]	Wheat[4]	Corn	Oats	Clover	Wheat	Corn	Oats	Soybeans	Wheat	Corn	Oats	Clover	Wheat	Corn
401	0	35.8	47.8	(1.60)	16.2	43.9	65.5	(2.69)	25.5	40.7	41.1	(1.18)	21.7	56.3	25.3	(2.73)	10.7	44.4
402	M	40.3	48.3	(1.73)	18.2	66.8	70.5	(2.97)	26.2	69.6	45.6	(1.59)	26.6	74.0	42.5	(2.80)	25.2	59.0
403	ML	41.3	53.8	(1.74)	17.6	68.8	58.6	(3.06)	27.5	69.7	43.8	(1.69)	31.0	77.8	52.0	(3.36)	35.2	61.0
404	MLP	41.3	48.4	(1.63)	23.7	66.1	54.2	(3.03)	27.8	70.1	43.9	(1.74)	33.6	79.8	53.1	(3.92)	38.0	63.6
405	0	42.2	48.4	12.3	18.8	49.1	73.9	.05	24.8	48.5	37.8	12.2	18.4	54.8	26.9	(2.66)	14.3	40.8
406	R	39.2	49.7	12.4	21.0	58.8	68.6	.03	26.8	60.7	38.8	14.1	22.5	72.9	35.6	(2.97)	21.3	51.2
407	RL	40.0	42.3	15.0	20.7	61.3	58.6	.04	30.7	65.1	44.1	13.7	28.2	80.2	49.4	(3.98)	29.2	52.6
408	RLP	39.0	47.0	14.0	23.8	55.4	58.9	.06	31.8	64.4	38.3	15.4	31.4	80.0	53.4	(4.09)	36.0	52.2
409	RLPK	35.2	47.8	13.8	23.0	59.1	52.5	.05	35.8	71.9	43.0	16.4	31.8	86.8	44.8	(4.21)	38.5	54.8
410	0	43.0	48.0	(1.50)	15.0	49.0	72.7	(2.85)	25.7	45.6	30.5	(1.28)	20.5	58.3	33.0	(2.59)	12.0	39.8

[1]No soil treatment. [2]Residues only. [3]Wheat winterkilled; barley grown as a substitute crop. [4]No manure. [5]Residues and lime only.

FIG. 4.—CLOVER ON UNTREATED LAND, DIXON FIELD
A cutting of red-clover hay obtained from an untreated plot. Compare with Fig. 5.

Limestone in addition to organic manures has, with a single exception, effected more or less improvement, probably sufficient to cover the expense of application.

Rock phosphate, as usual, shows up to best advantage used with residues on the wheat crop. The effect on other crops, however, has been such that the increases in yield are not sufficient to cover the cost of the application under present market conditions.

TABLE 8.—DIXON FIELD: SERIES 100, 200, 300, 400, SUMMARY OF CROP YIELDS
Average Annual Yields 1912-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *15 crops*	Oats *14 crops*	Wheat *11 crops*	Barley *1 crop*	Clover[1] *9 crops*	Soybeans *4 crops*
1	0	36.3	49.0	20.3	43.3	(1.73)	(1.46)
2	M	55.6	61.7	26.9	46.4	(2.44)	(1.78)
3	ML	59.7	65.5	31.0	55.2	(2.70)	(1.92)
4	MLP	62.3	67.3	34.2	58.3	(2.82)	(1.97)
5	0	42.6	54.4	21.7	49.5	(1.35)	11.8
6	R	50.5	58.7	24.8	53.8	(1.47)	13.5
7	RL	56.4	62.6	28.0	54.5	(1.77)	13.3
8	RLP	57.7	65.1	32.9	59.0	(2.04)	13.3
9	RLPK	61.1	64.6	33.7	56.9	(2.18)	14.0
10	0	41.3	52.0	20.0	45.4	(1.89)	(1.45)
	Crop Increases						
	M over 0	19.3	12.7	6.6	3.1	(.71)	(.32)
	R over 0	7.9	4.3	3.1	4.3	(.12)	1.7
	ML over M	4.1	3.8	4.1	8.8	(.26)	(.14)
	RL over R	5.9	3.9	3.2	.7	(.30)	− 0.2
	MLP over ML	2.6	1.8	3.2	3.1	(.12)	(.05)
	RLP over RL	1.3	2.5	4.9	4.5	(.27)	0.0
	RLPK over RLP	3.4	− .5	.8	−2.1	(.14)	.7

[1]Including some seed crops evaluated in this summary as hay.

FIG. 5.—CLOVER ON TREATED LAND, DIXON FIELD
A cutting of red-clover hay produced under the residues-limestone-phosphate treatment.

Altho potassium has produced an average increase of 3.5 bushels an acre in corn, on other crops the effects are such as to render its use unprofitable in growing these common field crops.

Special Phosphate Experiments

A problem of especial interest arising out of the experience of this and other fields concerns the merits of rock phosphate as compared with the more readily soluble phosphates, such as bone meal and acid phosphate.

In order to provide for some additional investigations on this phosphate problem, the plots on Series 100, 200, 300, and 400 were divided in 1924 into north and south halves. The plots on the south halves of all series continue under the original soil treatment, but the plots on the north halves receive the treatment designated in Table 9. No more rock phosphate will be applied to the phosphate plots on the south halves, these plots having received a total of 8,000 pounds an acre. The same holds true for the north half of Plot 9 of all series.

On the north halves, the phosphatic fertilizers and gypsum are applied twice in the rotation—half of the rotation quota being applied ahead of wheat and half ahead of corn—at the following annual acre-rates: rock phosphate, 500 pounds; acid phosphate, 200 pounds; bone meal, 200 pounds; gypsum, 200 pounds.

The minimum amount of limestone necessary to the successful growth of clovers will be applied to Plots 1-N and 10-N, on all series, 4,000 pounds per acre having been applied in 1924.

Owing to the short time thru which these experiments have been continued, a summary of the results is scarcely warranted at this time, but the complete data are given as a matter of record in Table 9.

TABLE 9.—DIXON FIELD: SPECIAL PHOSPHATE EXPERIMENTS, SERIES 100, 200, 300, 400, DIVIDED PLOTS, 1924-1926
Annual Crop Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment	1924				1925				1926			
		Series 100 Oats	Series 200 Corn	Series 300 Wheat	Series 400 Clover	Series 100 Clover	Series 200 Oats	Series 300 Corn	Series 400 Wheat	Series 100 Wheat	Series 200 Clover	Series 300 Oats	Series 400 Corn
						South Half							
1	0	42.2	41.6	20.0	(2.73)	(2.29)	45.0	55.8	10.7	38.0	(.74)	22.8	44.4
2	M	57.2	57.6	33.0	(2.80)	(2.34)	60.6	85.0	25.2	41.7	(1.84)	40.3	59.0
3	ML	67.2	62.4	41.2	(3.36)	(2.25)	75.3	87.6	35.2	45.8	(2.15)	50.6	61.0
4	MLrP	71.6	62.0	38.2	(3.92)	(2.30)	70.0	92.6	38.0	48.2	(2.20)	45.0	63.6
5	0	45.9	45.0	26.2	(2.66)	(2.10)	50.3	63.0	14.3	32.0	(.87)	26.9	40.8
6	R	60.3	51.8	27.3	(2.97)	(1.02)	52.2	64.0	21.3	40.3	(1.02)	34.1	51.2
7	RL	79.7	57.2	35.5	(3.98)	(1.21)	55.9	79.6	29.2	43.5	(1.58)	43.8	52.6
8	RLrP	78.4	59.6	41.3	(4.09)	(1.64)	71.9	81.0	36.0	45.8	(2.26)	43.8	52.2
9	RLrPK	69.7	62.2	37.7	(4.21)	(1.80)	76.3	81.2	38.5	44.3	(2.28)	48.8	54.8
10	0	41.3	45.8	20.0	(2.59)	(2.13)	45.9	66.4	12.0	28.3	(.70)	24.7	39.8
						North Half							
1	RL	36.3	43.4	13.5	(2.25)	(1.00)	47.2	55.8	6.0	36.3	(.95)	25.9	42.0
2	MrP	60.3	62.8	30.8	(3.17)	(2.44)	60.0	85.0	20.3	39.2	(1.86)	40.3	59.4
3	MLbP	63.4	62.8	29.2	(3.51)	(2.53)	72.2	89.6	27.5	46.2	(2.17)	49.7	57.6
4	MLrP	74.1	58.0	32.2	(4.01)	(2.60)	78.1	91.2	27.8	46.2	(2.25)	50.0	58.2
5	RaP	51.6	44.8	26.3	(2.73)	(.99)	58.8	66.8	19.5	41.5	(1.36)	32.2	42.0
6	RrP	54.4	50.2	25.3	(2.67)	(1.03)	55.3	73.0	15.2	42.7	(1.50)	36.9	50.2
7	RLaP	76.6	50.2	40.8	(4.06)	(1.35)	74.4	77.2	35.7	47.3	(2.04)	50.0	49.2
8	RLrP	63.8	55.0	39.3	(4.40)	(1.61)	77.5	78.6	30.2	42.7	(2.22)	53.4	48.4
9	RLrPK—Gypsum	70.3	53.4	37.2	(4.55)	(1.80)	80.9	85.0	36.3	47.5	(2.41)	58.1	57.8
10	RLrP	41.3	40.0	19.7	(2.63)	(1.11)	55.9	71.6	11.8	34.8	(1.27)	34.7	45.4

TABLE 10.—DIXON FIELD, SERIES 500, 600, 700, 800
Annual Crop Yields, 1913-1926—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1913 Potatoes[1]	1914 Potatoes[1]	1915 Barley hay[1]	1916 Alfalfa[1]	1917 Alfalfa[1]	1918 Alfalfa[1]	1919 Alfalfa[1]	1920 Soy-beans[1]	1921 Corn[5]	1922 Oats	1923 Corn	1924 Corn	1925 Oats	1926 Alfalfa
501N	K	109.2	87.0	(.94)	(1.93)	(1.30)	(1.12)	(2.39)	(1.97)	63.2	70.9	52.2	29.8	51.6	(1.56)
501S	0				(2.61)	(1.45)	(1.50)	(.95)	(1.30)	68.0	67.2	51.2	33.4	49.7	(1.63)
502N	MK	124.8	120.2	(1.71)	(4.21)	(1.68)	(1.66)	(3.15)	(2.06)	70.4	84.4	59.2	51.4	62.8	(3.03)
502S	M				(4.50)	(1.70)	(3.37)	(2.73)	(1.97)	75.6	78.4	58.2	45.4	59.1	(2.96)
503N	MLK	127.9	106.3	(1.70)	(4.02)	(1.94)	(3.25)	(4.30)	(2.15)	76.0	84.1	53.8	55.0	71.6	(5.03)
503S	ML				(4.37)	(1.99)	(3.70)	(3.30)	(1.93)	77.8	79.1	62.0	51.8	66.9	(4.86)
504N	MLPK	134.7	119.1	(1.51)	(4.00)	(2.15)	(2.77)	(3.97)	(2.11)	74.8	87.5	50.8	56.2	73.1	(5.10)
504S	MLP				(4.28)	(2.15)	(3.42)	(3.94)	(2.01)	76.2	79.4	56.4	49.8	65.0	(5.14)
		Alfalfa hay[2,3]	Alfalfa hay[2]	Potatoes	Potatoes	Alfalfa[4]	Alfalfa	Alfalfa	Alfalfa[4]	Corn	Corn	Oats	Corn	Corn	Oats
601N	K	....	(6.82)	95.5	20.8	.....	(2.74)	(4.08)	.....	68.0	85.6	54.1	39.2	48.4	40.6
601S	0	....		110.3	24.2	.....	(1.73)	(3.80)	.....	65.2	75.4	67.5	38.6	52.6	39.4
602N	MK	....	(6.30)	177.2	65.8	.....	(5.27)	(4.82)	.....	78.6	86.2	65.6	58.0	66.6	44.1
602S	M	....		151.2	75.0	.....	(4.81)	(4.39)	.....	75.0	88.4	66.9	54.2	74.2	51.3
603N	MLK	....	(6.33)	162.5	60.0	.....	(5.46)	(5.50)	.....	78.6	90.4	72.5	60.8	78.0	63.8
603S	ML	....		130.0	70.8	.....	(6.23)	(4.63)	.....	73.4	85.6	70.9	57.2	73.4	56.6
604N	MLPK	....	(6.09)	147.3	62.5	.....	(6.10)	(6.00)	.....	76.8	89.8	72.5	60.0	71.8	65.0
604S	MLP	....		96.0	65.0	.....	(5.73)	(4.99)	.....	76.8	79.8	68.8	59.6	72.0	56.3

[1]No potassium. [2]No manure or potassium. [3]Plots harvested together; average yield 5.35 tons an acre. [4]Alfalfa seeding. [5]Rotation changed to corn, corn, oats (sweet clover), alfalfa.

TABLE 10.—DIXON FIELD, SERIES 500, 600, 700, 800—*Concluded*

Plot No.	Soil treatment applied	1913 Alfalfa[2,3]	1914 Alfalfa[2]	1915 Alfalfa[2]	1916 Alfalfa[2]	1917 Potatoes	1918 Potatoes	1919 Alfalfa	1920 Alfalfa	1921 Alfalfa	1922 Corn	1923 Corn	1924 Oats	1925 Corn	1926 Corn
701N	K	.....	(5.63)	(4.91)	(5.00)	66.7	71.7	(1.83)	(4.08)	(5.14)	84.2	58.4	80.3	73.6	31.2
701S	0	.....		(4.68)	(4.83)	47.5	48.3	(1.79)	(3.88)	(4.84)	81.6	52.4	72.2	69.6	28.2
702N	MK	.....	(5.39)	(4.71)	(4.23)	100.0	142.2	(2.10)	(4.19)	(5.43)	93.8	70.8	82.8	77.8	52.2
702S	M	.....		(4.70)	(4.95)	76.7	124.2	(2.11)	(3.71)	(4.94)	85.8	59.4	80.0	72.4	43.8
703N	MLK	.....	(5.91)	(4.81)	(5.48)	102.5	140.0	(2.49)	(4.72)	(5.49)	92.2	71.8	85.3	81.4	50.8
703S	ML	.....		(5.06)	(5.00)	81.7	123.3	(2.21)	(4.49)	(4.92)	88.0	62.4	76.9	79.0	39.6
704N	MLPK	.....	(5.39)	(4.89)	(4.83)	95.0	155.0	(2.26)	(4.56)	(5.26)	96.0	73.8	85.3	78.2	42.0
704S	MLP	.....		(4.77)	(4.21)	100.8	133.5	(1.97)	(3.80)	(4.78)	86.6	59.6	76.3	82.0	40.8
		Alfalfa[2,3]	Alfalfa[2]	Alfalfa[2]	Alfalfa[2]	Alfalfa[2,4]	Alfalfa[2]	Potatoes	Potatoes	Oats	Alfalfa	Alfalfa	Alfalfa	Alfalfa	Corn
801N	K	.....	(5.39)	(4.64)	(4.49)	.....	(3.90)	38.3	46.0	48.4	(4.23)	(4 12)	(2.69)	(3.78)	40.4
801S	0	.....		(4.52)	(4.26)	.....	(4.22)	36.3	36.2	40.9	(4.11)	(4.36)	(3.17)	(4.02)	35.0
802N	MK	.....	(5.45)	(4.76)	(5.14)	.....	(4.28)	64.0	92.2	53.1	(5.63)	(4.42)	(3.15)	(4.08)	53.2
802S	M	.....		(4.50)	(4.52)	.....	(4.56)	56.7	80.8	47.5	(5.24)	(4.35)	(3.28)	(4.19)	54.8
803N	MLK	.....	(5.40)	(4.62)	(4.47)	.....	(4.43)	49.5	98.7	52.5	(5.64)	(4.99)	(3.38)	(4.51)	58.8
803S	ML	.....		(4.56)	(4.22)	.....	(4.40)	40.8	98.0	49.7	(5.33)	(4.69)	(3.43)	(4.19)	56.2
804N	MLPK	.....	(6.08)	(5.09)	(4.45)	.....	(4.73)	71.7	109.0	50.3	(5.75)	(5.20)	(3.21)	(4.91)	62.2
804S	MLP	.....		(4.72)	(3.49)	.....	(4.22)	58.3	104.5	50.3	(5.34)	(4.98)	(3.13)	(4.60)	58.8

[2]No manure or potassium. [3]Plots harvested together; average yield 5.35 tons an acre. [4]Alfalfa seeding.

The 500, 600, 700, and 800 Series

When the field was established Series 500, 600, 700, and 800 were left unplotted and were seeded to alfalfa. In 1912 they were plotted for a potato-alfalfa rotation. It was planned to grow potatoes two years in succession on the same land, while alfalfa was to be grown six years. The initial application of limestone was at the rate of 4 tons an acre. Subsequent applications were at the rate of 4 tons an acre when the land was seeded to alfalfa. Rock phosphate was applied at the annual acre-rate of 500 pounds. Manure was applied at the rate of 15 tons an acre for each potato crop. Beginning with 1915 potassium sulfate was applied to the north half of all plots at the rate of 200 pounds an acre for each potato crop. In 1921 the rotation on these series was changed to one of corn, corn, and oats with sweet clover seeding on Plots 2, 3, and 4, alfalfa occuping the fourth series for four years. The fertilizers on all series were evened up at this time, and no more will be applied for an indefinite period.

Table 10 serves to furnish an outline of the cropping history of these series. The work is summarized in Table 11, which gives the average annual acre yields for the years since the plots have been under their complete treatments. The lower part of the table gives the possible comparisons of the various combinations expressed as crop increases.

TABLE 11.—DIXON FIELD, SERIES 500, 600, 700, 800: SUMMARY OF CROP YIELDS
Average Annual Yields, 1915-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Potatoes *6 crops*	Alfalfa *12 crops*	Corn *12 crops*	Oats *6 crops*
1N	K	56.5	(2.94)	56.2	57.7
1S	0	50.5	(2.78)	54.3	56.1
2N	MK	106.9	(3.51)	68.2	65.5
2S	M	94.1	(3.33)	65.6	63.9
3N	MLK	102.2	(3.93)	70.6	71.1
3S	ML	90.8	(3.75)	65.5	66.7
4N	MLPK	106.8	(4.03)	69.4	72.3
4S	MLP	93.0	(3.70)	66.5	66.0
	Crop Increases				
	For Manure				
	M over 0	43.6	(.55)	11.3	7.8
	MK over K	50.4	(.57)	12.0	7.8
	For Limestone				
	ML over M	−3.3	(.42)	− .1	2.8
	For Phosphorus				
	MLP over ML	2.2	(− .05)	1.0	− .7
	MLPK over MLK	4.6	(.10)	−1.2	1.2
	For Potassium				
	K over 0	6.0	(.16)	1.9	1.6
	MK over M	12.8	(.18)	2.6	1.6
	MLK over ML	11.4	(.18)	5.1	4.4
	MLPK over MLP	13.8	(.33)	2.9	6.3

The beneficial results with stable manure are very pronounced, confirming those obtained on the other series discussed above.

Disregarding the effect on potatoes, which are not now being grown, the response to limestone resembles, in a general way, that on the major series described above. Moderate increases are produced, the value of which would probably just about cover the cost of application.

The effect of rock phosphate on these series has been very indifferent, and its application has been attended by a financial loss.

Potassium treatment appears in four combinations if we include the plot where it is used alone. Where used in any of the combinations with manure, potassium produced a considerable increase in the potato yield, and where limestone enters the combination, a significant increase in yield of second-year corn is found. Where combined with manure and phosphate, a third of a ton increase in alfalfa was produced.

THE VIENNA FIELD

Inasmuch as Lee county embraces in its Yellow Silt Loam and certain other types considerable land that is subject to destruction thru erosion or washing, an account of the experiments on the Vienna field should be of interest in this Report.

The Vienna field, located near Vienna in Johnson county, is representative of the sloping, erodible land so prevalent in that section of the state. Experiments were conducted for nine years for the purpose of testing different methods of reclaiming the land and preventing erosion. A brief description of this work is given in the following paragraphs.

The whole field with the exception of about three acres had been abandoned because so much of the surface soil had washed away and there were so many gullies as to render further cultivation of this land unprofitable. The field was divided into five sections. The sections designated as A, B, and C were divided into four plots each, and D into three plots. On section A, which included the steepest part of the area and contained many gullies, the land was built up into terraces at vertical intervals of 5 feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

On section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges sufficiently high so that on the occasion of a heavy rainfall if the water breaks over, it will run over in a broad sheet rather than in narrow channels. At the steepest part of the slope hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about eight loads of manure per acre were turned under each year for the corn crop.

FIG. 6.—VIEW OF UNIMPROVED HILLSIDE LAND TAKEN JUST OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 7

The land on section D was washed to about the same extent as that of section C. As a check on the different methods of reducing erosion, the land on section D was farmed in the most convenient way, without any special effort being made to prevent washing.

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

Sections A, B, C, and D were not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

FIG. 7.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD. THIS LAND FORMERLY HAD BEEN BADLY ERODED. COMPARE WITH FIG. 6

TABLE 12.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields, 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(0.68)
B	Embankments and hillside ditches	32.4	12.7	(0.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(0.80)
D	Check	14.1	4.6	(0.21)

Limestone was applied to the entire field at the rate of 2 tons per acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except D which had but three plots.

Table 12 contains a summarized statement of the results obtained. These results indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels for series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 6 and 7 will serve to indicate the possibility of improving this worthless eroded land.

THE OQUAWKA FIELD

In 1913 the University came into possession of a tract of Dune Sand, Terrace, in Henderson county, near the Mississippi river, upon which an experiment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. With this implement the seed is covered about one-half inch deep.

Table 13 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 49.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been greatly increased. The limestone has also been instrumental in producing good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite indifferent to treatment with rock phosphate. The analyses show, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 8.—ALFALFA ON THE OQUAWKA EXPERIMENT FIELD

These pictures show the possibility of improving this unproductive sandy land on the Oquawka field. Both plots were seeded alike to alfalfa. Where manure alone was applied, the crop was a total failure, but where limestone in addition to manure was applied, nearly 4½ tons of alfalfa hay was obtained as the season's yield.

become profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

Altho the results show an increase of nearly 3 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment. The slight increase for the potassium treatment appearing in the other crops can scarcely be considered significant.

A significant fact which the general summary does not bring out is that the improvement under favorable treatment has been progressive, as evidenced by a very marked upward trend in production after the first few years. For example, it may be noted that the yield of corn under the limestone-residues treatment has been 36.7 bushels an acre as an average for the 11 crops since full treatment started, but if we take an average of the last five crops the yield rises to 45.7 bushels. Likewise the wheat under this same treatment gives for the 11-year average 13.9 bushels, but the last five years has given 19.6 bushels.

Experience thus far shows rye to be better adapted to this land than wheat, and, under good treatment, both alfalfa and sweet clover thrive better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

TABLE 13.—OQUAWKA FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1915-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *11 crops*	Soybeans[1] *11 crops*	Wheat *11 crops*	Sweet Clover[2] *7 crops*	Rye *9 crops*	Alfalfa *8 crops*
1	0	19.8	(1.01)	7.7	0.00	11.9	(.35)
2	M	25.0	(1.20)	10.9	0.00	13.3	(.56)
3	ML	32.2	(1.60)	14.6	1.14	24.5	(2.05)
4	MLP	31.9	(1.58)	15.0	1.14	23.0	(2.12)
5	0	20.1	(.78)	9.8	0.00	11.7	(.08)
6	R	21.8	(.82)	11.1	0.00	12.7	(.09)
7	RL	36.7	(1.25)	13.9	1.57	24.3	(1.82)
8	RLP	36.1	(1.25)	14.1	1.43	24.3	(1.79)
9	RLPK	39.0	(1.17)	13.3	1.67	26.5	(1.87)
10	0	19.1	(.72)	8.8	0.00	(10.7)	(.02)
	M over 0	5.2	(.19)	3.2	0.00	1.4	(.21)
	R over 0	1.7	(.04)	1.3	0.00	1.0	(.01)
	ML over M	7.2	(.40)	3.7	1.14	11.2	(1.49)
	RL over R	14.9	(.43)	2.8	1.57	11.6	(1.73)
	MLP over ML	− .3	−(.02)	.4	0.00	− 1.5	(.07)
	RLP over RL	− .6	(0.00)	.2	− .14	0.0	−(.03)
	RLPK over RLP	2.9	−(.08)	− .8	.24	2.2	(.08)

[1]Eleven regular crops together with the extra crop described in Footnote 2 averaged as 11 crops. Several crops which were harvested as seed are evaluated in this summary as hay.
[2]Some hay evaluated as seed. In 1918, the sweet clover was killed by early cutting for a hay crop. Soybeans were seeded in July and the ensuing crop is included in the soybean average.

THE MANITO FIELD

The results secured on the Manito experiment field, which was located on Deep Peat and which was in operation during the years 1902 to 1905 inclusive, are presented in Table 14.

The field consisted of ten plots receiving the treatments indicated in the table. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. However, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons an acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the total yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) appear to be insufficient.

TABLE 14.—MANITO FIELD: DEEP PEAT
Annual Corn Yields—Bushels per acre

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905
1	None	10.9	8.1	None	17.0	12.0
2	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs. Kainit, 1200 lbs	49.6	47.3
4	Kainit, 600 lbs Acidulated bone, 350 lbs	30.3	33.3	Kainit, 1200 lbs Steamed bone, 395 lbs.	53.5	47.6
5	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs	44.5	47.3
8	Kainit, 600 lbs	36.8	37.7	Kainit, 600 lbs	44.0	46.0
9	Kainit, 300 lbs	26.4	25.1	Kainit, 300 lbs	41.5	32.9
10	None	[1]	14.9	None	26.0	13.6

[1]No yield was taken in 1902 because of a misunderstanding.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1925
33 Saline, 1926
34 Marion, 1926
35 Will, 1926
36 Woodford, 1927
37 Lee, 1927

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT NO. 38

OGLE COUNTY SOILS

By R. S. SMITH, O. I. ELLIS, E. E. DeTURK, F. C. BAUER, AND L. H. SMITH

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URBANA, ILLINOIS, SEPTEMBER, 1927

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Ogle county was conducted, and Mr. R. W. Dickenson who, as leader of the field party, was in direct charge of the mapping.

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OGLE COUNTY SOILS

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OGLE COUNTY SOILS

By R. S. SMITH, O. I. ELLIS, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

LOCATION AND CLIMATE OF OGLE COUNTY

Ogle county is situated in the northwestern part of Illinois, about 24 miles south of the Wisconsin state line. It comprizes about 754 square miles and is traversed almost centrally from northeast to southwest by Rock river. Most of the county is tillable with the exception of the rough and broken land along Rock river. Approximately 2½ percent of the area of the county is so rough and broken that it should be left permanently in timber.

The weather data collected at Dixon, Lee county, for the fourteen-year period from 1911 to 1924 are used to indicate the climatic conditions of this region. The greatest range in temperature for any one year was 122 degrees, in 1919. The highest temperature recorded was 104°, in 1921; the lowest, 24° below zero, in 1919. The average date of the last killing frost in spring for this period was May 5; the earliest in autumn, October 16. The average length of the growing season is therefore about 164 days.

The average annual rainfall for this period was 32.28 inches. The rainfall by months was as follows: January, 1.17 inches; February, 1.33; March, 2.79; April, 2.70; May, 3.50; June, 3.82; July, 3.29; August, 3.57; September, 3,83; October, 3.01; November, 1.69; December, 1.55.

AGRICULTURAL PRODUCTION

Ogle county is regarded as distinctly agricultural, with about 95 percent of the land tillable. The Census of 1920 reports 2,784 farms in the county, as compared with 2,962 in 1910 and 3,093 in 1900.

The agriculture of the county includes grain farming, dairying, and livestock farming. It may be classed as general farming, with great emphasis placed on dairying and livestock, including the production of beef cattle, hogs, and, to less extent, sheep. It will be noted in the following tables that the total value of all livestock, for 1919, as reported in the Fourteenth Census, was about 8 million dollars, and that the total value of all crops for this same year was 13½ million dollars. It is interesting to note in this connection that very little grain is shipped out of the county, most of it being used for feeding either on the farm where it is grown or on neighboring farms. Dairying is the predominant type of farming on the rolling and broken land adjacent to Rock river.

The following figures taken from the Fourteenth Census indicate the relative importance of the various kinds of livestock for 1920, and of livestock products for 1919:

---

[1] R. S. Smith, in charge of soil survey mapping; O. I. Ellis, Assistant Chief in soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

Animals and Animal Products	*Number*	*Value*
Horses	19,205	$1,723,621
Mules	423	47,912
Beef cattle	39,656	2,362,449
Dairy cattle	23,898	1,772,073
Sheep	8,423	124,367
Swine	70,533	1,705,248
Poultry	325,240	338,140
Eggs and chickens	.....	742,495
Dairy products	.....	1,196,735
Wool	51,165 lbs.	28,037

The report gives the total value of livestock as about 7¾ million dollars.

The principal field crops are corn, oats, wheat, barley, hay, and clover. According to the Census, the total value for all crops in 1919 was $13,585,000. The following figures give the acreage and yield of some of the more important crops for the year 1919:

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	107,799	4,298,629 bu.	39.8 bu.
Oats	91,478	3,016,268 bu.	32.8 bu.
Wheat	26,461	433,121 bu.	16.3 bu.
Barley	11,854	293,959 bu.	24.7 bu.
Rye	4,608	67,455 bu.	15.0 bu.
Timothy	10,290	12,425 tons	1.20 tons
Timothy and clover	31,428	44,299 tons	1.09 tons
Clover	6,271	9,723 tons	1.55 tons
Silage crops	10,101	76,514 tons	7.56 tons
Corn for forage	12,387	31,361 tons	2.53 tons

Figures furnished by the U. S. Department of Agriculture give the following acre-yields for the ten-year period 1911-1920: corn, 36.2 bushels; oats, 36.5 bushels; tame hay, 1.41 tons; winter wheat, 17.5 bushels.

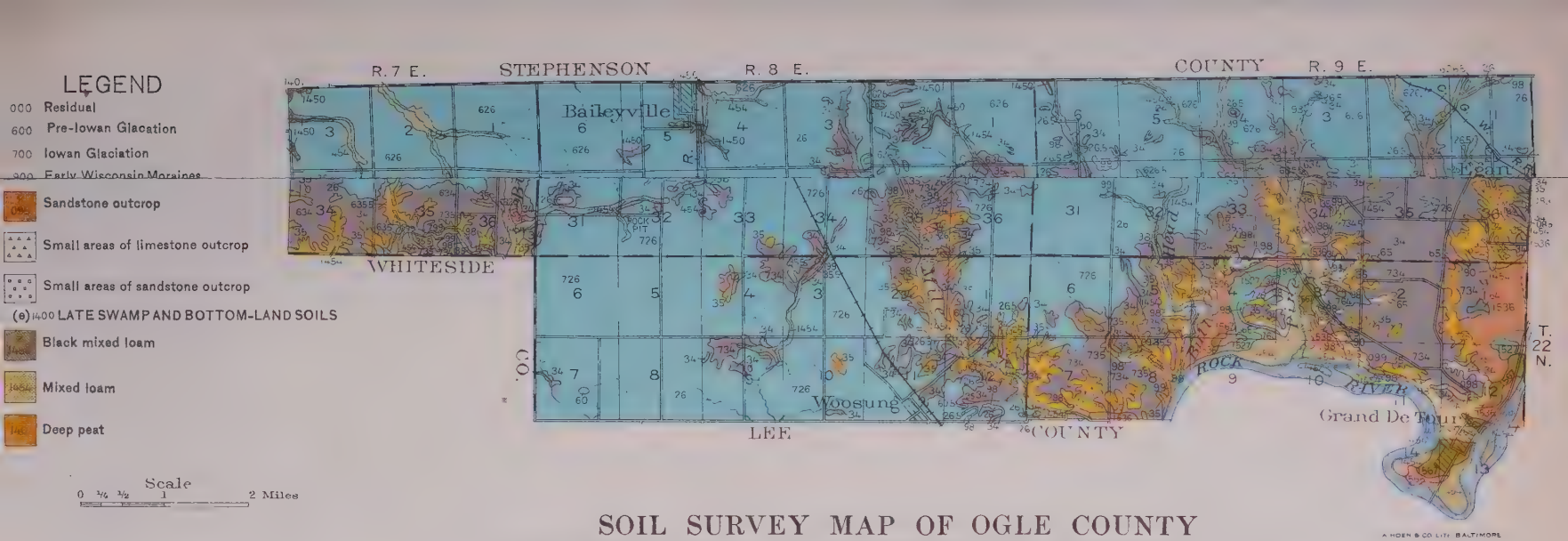
The fruit industry is not developed in Ogle county. Very little fruit is grown aside from small plantings for home use.

SOIL FORMATION

GEOLOGICAL ASPECTS

One of the most important periods in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during which and immediately following, the material that later formed the mineral portion of the soils was being deposited. During the Glacial period, great ice sheets moved southward from the centers of accumulation in Labrador, in the Hudson Bay region, and in the northern Rocky mountains. At least six great ice movements took place, each of which covered a part of northern United States, altho the same parts were not covered during each advance.

The glaciations of northwestern Illinois, including the area occupied by Ogle county, have been a matter of uncertainty ever since the first classification of the drift sheets of this region. As explained on page 30, the system of numbering the soil types is based largely upon the glaciations as outlined on the glacial map prepared many years ago by Leverett. This map shows Ogle county as being covered mainly by the Iowan and Pre-Iowan glaciations but in the light of more recent evidence, the most of the county is now considered as belonging to



SOIL SURVEY MAP OF OGLE COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

the Illinoisan. It may be said, however, that so far as the identity of the soil types are concerned, the matter is not important. The eastern end of the county was probably invaded by a lobe of the early Wisconsin glaciation and the southeastern corner of the county is occupied by Wisconsin moraines.

The drift averages about 4 feet in depth on the upland, ranges from 150 to 400 feet deep in the preglacial valleys, and is about 100 feet deep on the Wisconsin moraine in the southeastern corner of the county. The loess or loess-like silt which constitutes the surface material varies from about 20 inches in depth in the eastern part of the county to 6 or 7 feet in depth in the western part. The shallow blanket of loess and drift explains the frequent occurrence of rock outcrop and stony soil along Rock river and its tributaries, where the rolling topography has allowed the removal of the soil material by erosion.

CHANGES IN THE RIVER SYSTEMS

The drainage system of Ogle county has a complicated history. The preglacial Rock river flowed south from its present junction point with Kishwaukee river thru the eastern end of Ogle county. It cut a valley 3 to 5 miles wide thru most of its course and its depth below the present surface averages about 400 feet. The minor streams also have changed their courses and in some instances reversed their direction of flow. The gravel and sand ridges, known as eskers, also indicate major changes in the drainage channels of the county. Three of these eskers occur in Ogle county, known as the Adeline, Hazelhurst, and Stillman eskers.

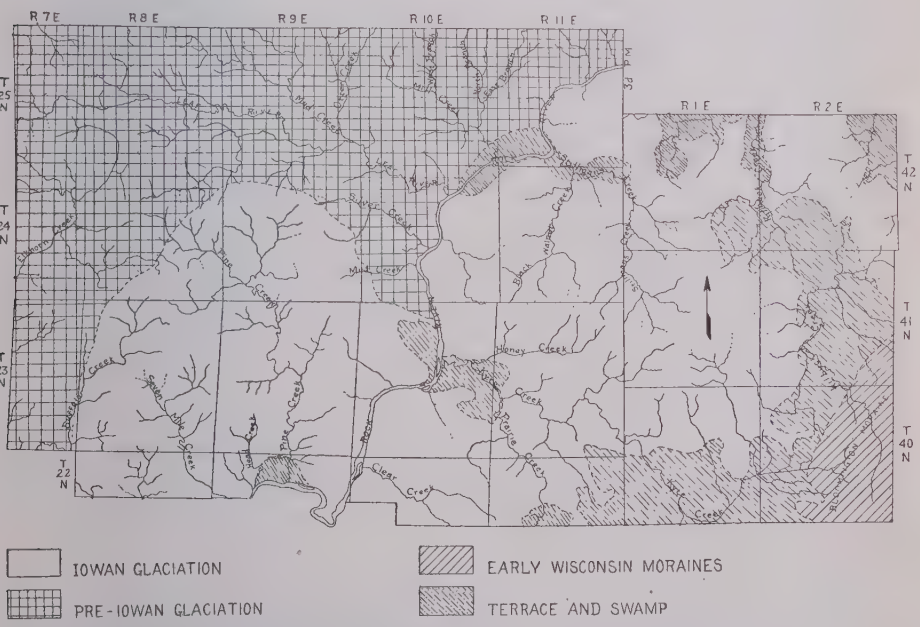


FIG. 1—DRAINAGE MAP OF OGLE COUNTY SHOWING STREAM COURSES, TERRACES AND SWAMP LANDS, AND GLACIATIONS
(Glaciations based on Leverett map)

PHYSIOGRAPHY AND DRAINAGE

The topography of Ogle county varies from flat to rolling, with rough and broken areas along Rock river and the others streams of the county. The flat topography is found in the terraces, while the undulating to rolling prevails in the upland prairie.

Rock river is the main drainage channel of the county and most of the minor streams flow into this river within the boundaries of the county. The accompanying drainage map shows the drainage of the county in detail.

The altitude of Ogle county varies from about 700 to 931 feet. The following figures give the altitudes for a few points in the county: Creston, 903 feet; Rochelle, 795; Oregon, 702; Forreston, 931; Byron, 726. The altitude of Bloomington moraine in the southeastern part of the county varies from about 850 to 910 feet.

SOIL DEVELOPMENT

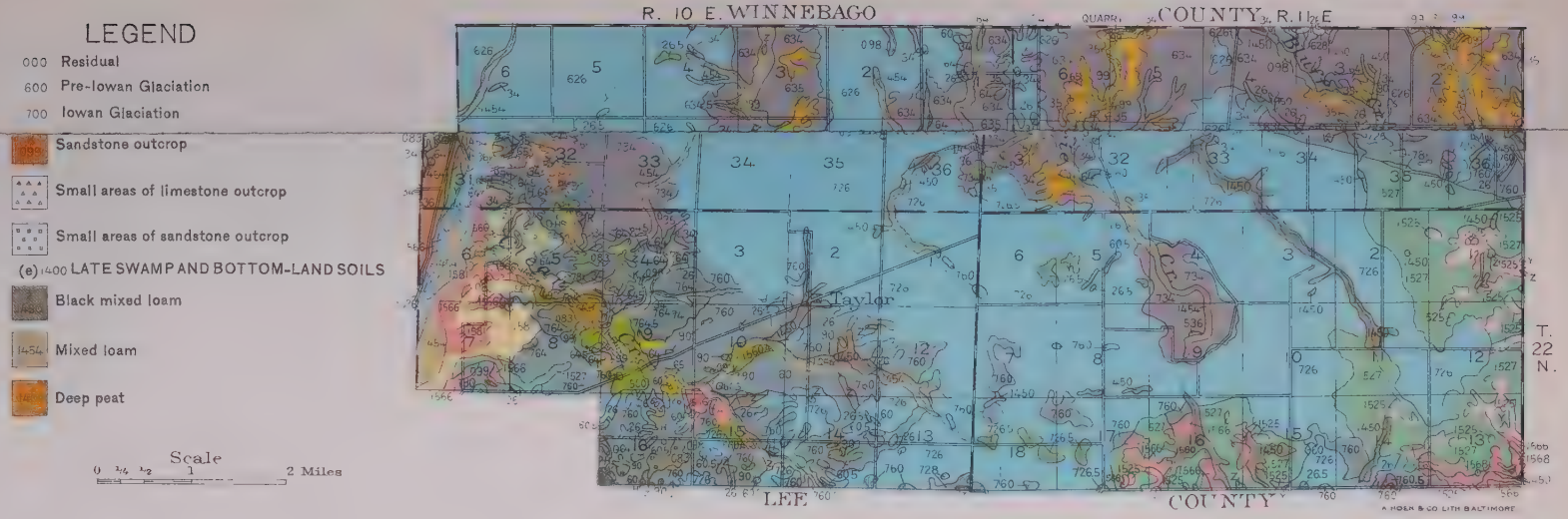
During the time which has elapsed since the last ice invasion, weathering and other processes have been active, resulting in the formation of the soils of the county as we know them today. When first deposited the general composition of any soil material, particularly loess, is rather uniform but with the passing of time various physical, chemical, and biological agencies of weathering form soil out of the parent material by some or all of the following processes: the leaching of certain elements, the accumulation of others; the chemical reduction of certain compounds, the oxidation of others; the translocation of the finer soil particles, and the arrangement of them into zones, or "horizons"; the accumulation of organic matter from the growth and decay of vegetable material. One of the very pronounced characteristics observed in most soils is that they are composed of more or less distinct strata, called horizons. As explained somewhat more fully in the Appendix, these horizons are named, from the surface down: A, the layer of extraction; B, the layer of concentration or accumulation; and C, less-altered material, or the layer in which weathering has had less effect. The development of horizons in a soil is an indication of its age.

Since the upland prairie of this region has been occupied, probably continuously, by grass vegetation, relatively large amounts of organic matter have accumulated, resulting in the formation of productive dark-colored soils. The areas adjacent to streams, which have been occupied by timber, are light-colored because of the relative deficiency of the surface soil in organic matter. The bottom-land soils are made up, for the most part, of alluvial material brought down from the uplands and deposited by the streams. These soils are to be regarded as relatively young or immature and therefore have not developed horizons as have the mature soils of the upland.

SOIL GROUPS

The soils of Ogle county are divided into five groups, as follows:

(a) *Upland Prairie Soils,* or dark-colored soils, usually rich in organic matter.



SOIL SURVEY MAP OF OGLE COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

(b) *Upland Timber Soils,* or light-colored upland soils, usually relatively poor in organic matter.

(c) *Terrace Soils,* including bench lands and second bottoms, formed by deposits from flooded streams overloaded with sediment.

(d) *Swamp and Bottom Lands,* including flood plains along streams and some poorly drained muck and peat areas.

(e) *Residual Soils,* including Rock Outcrop and Stony Loam areas and soils formed in place thru weathering of rocks.

Table 1 gives the area of each soil type in Ogle county and its percentage of the total area. It will be observed that 57.42 percent of the county consists of upland prairie, 20.50 percent of upland timber, 11.89 percent of terrace soils, 8.56 percent of swamp and bottom-land soils, and .95 percent of residual soils.

The accompanying map, appearing in three sections, shows the location and boundry lines of the various types.

For explanation concerning the classification of soils and interpretation of the maps and tables, the reader is referred to the first part of the Appendix to this report.

TABLE 1.—SOIL TYPES OF OGLE COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (600, 700, 900)			
626, 726, 926	Brown Silt Loam	384.24	245 914	50.91
626.5, 726.5	Brown Silt Loam On Limestone	1.38	883	.18
760	Brown Sandy Loam	42.21	27 014	5.59
660.5	Brown Sandy Loam On Limestone	1.64	1 050	.22
760.5	Brown Sandy Loam On Sandstone	.10	64	.02
628, 728	Brown-Gray Silt Loam On Tight Clay	.04	25	.01
781	Dune Sand	2.11	1 350	.28
690, 790	Gravelly Loam	1.58	1 011	.21
		433.30	277 311	57.42
	(b) Upland Timber Soils (600, 700, 900)			
634, 734, 934	Yellow-Gray Silt Loam	118.46	75 814	15.70
635, 735	Yellow Silt Loam	17.39	11 130	2.30
634.5, 734.5	Yellow-Gray Silt Loam On Limestone	.81	518	.11
635.5, 735.5	Yellow Silt Loam On Limestone	.89	570	.12
664, 764	Yellow-Gray Sandy Loam	14.77	9 453	1.95
665, 765	Yellow Sandy Loam	1.72	1 101	.22
664.5	Yellow-Gray Sandy Loam On Limestone	.09	58	.02
764.5	Yellow-Gray Sandy Loam On Sandstone	.63	403	.08
		154.76	99 047	20.50

TABLE 1.—SOIL TYPES OF OGLE COUNTY, ILLINOIS—*Concluded*

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(c) Terrace Soils (1500)			
1527	Brown Silt Loam Over Gravel	51.70	33 088	6.85
1525	Black Silt Loam	16.11	10 310	2.13
1566	Brown Sandy Loam Over Gravel	7.32	4 685	.97
1560.4	Brown Sandy Loam On Gravel	1.81	1 158	.24
1561	Black Sandy Loam	.25	160	.04
1536	Yellow-Gray Silt Loam Over Gravel	8.69	5 562	1.15
1567	Yellow-Gray Sandy Loam Over Gravel	2.19	1 402	.29
1564.4	Yellow-Gray Sandy Loam On Gravel	.46	294	.06
1581	Dune Sand	1.07	685	.14
1528	Brown-Gray Silt Loam On Tight Clay	.05	32	.01
1568	Brown-Gray Sandy Loam On Tight Clay	.05	32	.01
		89.70	57 408	11.89
	(d) Residual Soils (000)			
083	Sand	2.92	1 869	.38
098	Stony Loam—Limestone	3.62	2 317	.47
098	Stony Loam—Sandstone	.36	230	.05
099	Limestone Outcrop	.31	198	.04
099	Sandstone Outcrop	.08	51	.01
		7.29	4 665	.95
	(e) Late Swamp and Bottom-Land Soils (1400)			
1450	Black Mixed Loam	21.06	13 479	2.80
1454	Mixed Loam	43.08	27 571	5.71
1401	Deep Peat	.38	243	.05
		64.52	41 293	8.56
	(f) Miscellaneous			
	Water	4.82	3 085	.64
	Gravel Pit	.18	115	.03
	Rock Quarry	.07	45	.01
		5.07	3 245	.68
	Total	754.64	482 969	100.00

INVOICE OF THE ELEMENTS OF PLANT FOOD IN OGLE COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). These sampling strata correspond approximately in the common kinds of soil to 2 million pounds per acre of dry soil in the upper stratum, and to two times and three times this quantity in the middle and lower strata, respectively. This, of course, is a purely arbitrary division of

LEGEND

000 Residual

098 Stony loam—sandstone

099 Limestone outcrop

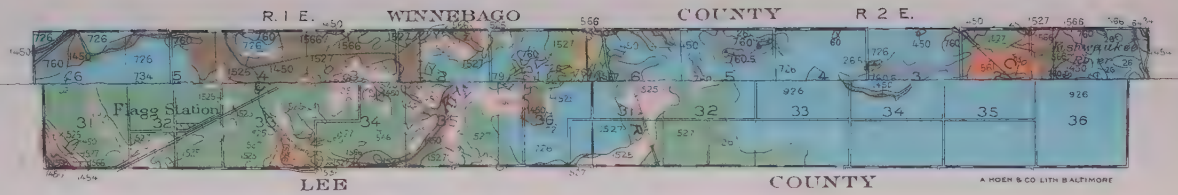
K 099 Sandstone outcrop

Small areas of limestone outcrop

Small areas of sandstone outcrop

Scale

0 ¼ ½ 1 2 Miles



(e) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

Black mixed loam

Mixed loam

Deep peat

SOIL SURVEY MAP OF OGLE COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

the soil section, very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to in describing the soil types as horizons A, B, and C. By this system of sampling we have represented separately three zones for plant feeding. The upper, or surface layer, includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, phosphate, or other fertilizing materials are incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed. It should be understood, however, that the rate of liberation from their insoluble forms, a matter of at least equal importance, is governed by many factors, and is therefore not necessarily proportional to the total amounts present.

For convenience in making application of the chemical analyses, the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In doing this the assumption is made that for ordinary types a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2 million pounds. It is understood, of course, that this value is only an approximation, but it is believed that with this understanding it will suffice for the purpose intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires to consider the information in that form.

With respect to the presence of limestone and acidity in different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages for the respective types, because of the extreme variations frequently found within a given soil type. In examining each soil type in the field, however, numerous qualitative tests are made which furnish general information regarding the soil reaction, and in the discussions of the individual soil types which follow, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping and soil treatment. It is often desirable, therefore, to determine the lime requirement for a given field and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (page 36).

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amounts of organic carbon, nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil of each type in Ogle county.

In connection with this table attention is called to the variation among the soil types with respect to their content of the different plant-food elements. It will be seen from the analyses that a variation in the organic-carbon content of the different soils is accompanied by a parallel variation in the nitrogen content. The organic-carbon content, which serves as a measure of the total organic

matter present, is usually 10 to 12 times that of the total nitrogen. This relationship is explained by the well-established facts that all soil organic matter contains nitrogen, and that most of the soil nitrogen (usually 98 percent or more) is present in a state of organic combination. This close relationship is also maintained in the middle and lower sampling strata.

The range in content of organic matter and nitrogen is very wide. The upland prairie soils are, for the most part, relatively high in these constituents. The upland timber soils are generally fairly low, with essentially no overlapping of organic matter in the two groups of soil types. The upland timber soils range from 19,660 pounds of organic carbon an acre in Yellow Silt Loam up to 30,410 pounds in Yellow-Gray Silt Loam, with an average of 24,460 pounds. The upland prairie soils, ranging from 30,500 to 49,380 pounds, average 41,330 pounds. One type, Dune Sand, is omitted from the average for upland prairie soils as given above, for, as is usually the case with very sandy soils, it is very deficient in organic matter and nitrogen, the organic carbon amounting to only 15,640 pounds an acre in the surface stratum.

While most soils should receive regular additions of organic materials in the form of green or animal manures and crop residues, in order to maintain an adequate supply of organic matter in actively decomposing condition, the frequent use of such materials is particularly necessary in the management of Dune Sand and similar types. The porous, open character of these soils permits the rapid oxidation of organic matter, so that it disappears from such soil much more rapidly than from the heavier types. Dune Sand is, in fact, but little more than the skeleton of a soil and cannot readily be brought up to, and maintained in, a state of productiveness without first incorporating active organic materials in it, and continuing with frequent subsequent additions. The soil is usually acid and hence limestone and legume green manures constitute the first and most important steps in converting it into a productive soil. Black Silt Loam contains the largest amount of organic carbon of any soil in the county, except Deep Peat, which is made up largely of organic matter. The organic carbon of Black Silt Loam amounts to 113,570 pounds an acre, with a corresponding nitrogen content of 12,990 pounds. While such soils as this will withstand more abuse by the practice of continuous cropping and are not so greatly in need of additions of organic materials as are soils containing only 20,000 to 30,000 pounds of organic carbon, yet the use of manure and the systematic growing of legumes for pasture and for plowing down serve to renew the active organic material in the soil in a way which is reflected in increases of crop yields.

Other elements are not so closely associated with each other as organic matter and nitrogen. There is some degree of correlation, however, between sulfur, another element used by growing plants, and organic carbon. This is because a considerable tho varying proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of the organic matter. Most of the Ogle county soils are fairly well supplied with sulfur. It ranges, in the surface soil, from a minimum of 260 pounds an acre in Dune Sand up to 3,550 pounds in Deep Peat. Excluding Deep Peat, the sulfur content of Ogle county soils amounts to one-half to two-thirds that of phosphorus. The sulfur available for crops is

affected not only by the soil supply, but also by that brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently it is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption the amount of sulfur thus added to the soil is relatively large. At Urbana, during the eight-year period from 1917 to 1924 there was added to the soil by the rainfall 3.5 pounds of sulfur an acre a month as an average. Similar observations have been made in other localities for shorter periods. At Spring Valley, in Bureau county, the rainfall during six summer months in 1921 brought down 34.5 pounds of sulfur an acre, or an average monthly precipitation of 5.75 pounds. The maximum for a single month was 8.77 pounds, in June. At Toledo, Cumberland county, from April to November 1922, the average precipitation was 3 pounds an acre a month. The precipitation at the various points in the state in a single month has varied from a minimum of .74 pound to 10.22 pounds an acre. These figures afford some idea of the amounts of sulfur added by rain and also of the wide variation in these amounts under different conditions. On the whole, these facts would indicate that the sulfur added from the atmosphere supplements that contained in the soil, so that there can be no extensive need for sulfur fertilizers in Ogle county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started at five experimental fields, namely, Raleigh, Toledo, Carthage, Hartsburg, and Dixon.

With regard to phosphorus, the upland timber soils as a group are found to be relatively low. One type, Black Silt Loam, is outstanding in its phosphorus content. This type in Ogle county is found in the terrace area, and the surface soil contains 2,380 pounds of phosphorus in an acre. This soil type not only exhibits an unusually high phosphorus content, but is high in organic matter, nitrogen, calcium, magnesium, and sulfur as well. This type, however, occupies only 16.11 square miles, or 2.13 percent of the area of the county.

Potassium is deficient in Deep Peat, as is usually the case with this soil type, the total amount in the upper 6⅔ inches of soil being only 4,290 pounds an acre. The sandy types in Ogle county are for the most part only slightly lower in potassium content than is the case with soils of finer texture. The Residual Sand areas, however, are particularly poor, not only in potassium but in all the other mineral elements. The potassium content of the samples obtained was only 3,060 pounds an acre, or about one-tenth the amount ordinarily found in the mineral soils. Sandy soils carry a considerable proportion of their potassium content in the coarse sand grains. The relatively small total surface exposed in the case of the coarse particles greatly lowers the solubility and availability of the potassium in sand soils. This is partly offset, however, by the greater depth of the feeding zone for crop roots in sandy soils as compared with the heavier types. The other types are normal in content of potassium.

The variation in the calcium and magnesium content in the soils of this county is wide. Nearly all the sand and sandy loam types are markedly low in both calcium and magnesium, containing, generally, less than 4,000 pounds of

magnesium in the surface 6⅔ inches, and somewhat larger amounts of calcium. The soils of finer texture are fairly well supplied with both of these elements.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper stratum or with each other, it is necessary to bear in mind that the data as given for the middle and lower sampling strata are on the basis of 4 million and 6 million pounds of soil, and should therefore be divided by two and three respectively before comparing them with each other or with the data for the upper stratum, which is on a basis of 2 million pounds.

With this in mind it will be noted in comparing the three strata with each other that some of the elements exhibit no consistent change in amount, either upward or downward, with increasing depth. This is true particularly of potassium. Others exhibit more or less marked variation in amount at the different levels. Furthermore, these variations as a rule, go in certain general directions, and by a careful study of them it is frequently possible to obtain clues as to the age or stage of maturity of the various soils and the nature of the processes going on in soil formation.

With the exception of Deep Peat it will be observed that all the soil types diminish rather rapidly in organic matter and nitrogen with increasing depth, and that this diminution is quite noticeable even in the middle stratum. The sulfur content decreases with increasing depth in nearly all cases. This is to be expected since a portion of the sulfur exists in combination with the soil organic matter which is more abundant in the upper strata, and also because inorganic forms of sulfur are not tenaciously retained by the soil against the leaching action of ground water. Phosphorus, on the other hand, is not removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in these forms in plant residues at the expense of the underlying strata. Evidently it is the second stratum (6⅔ to 20 inches) which furnishes most of the phosphorus thus moved upward. Consequently, in nearly all the soil types in Ogle county the surface soil contains a larger proportionate amount of phosphorus than the middle stratum, and in the majority of cases more than the lower stratum.

Two important basic elements, calcium and magnesium, have undergone some shifting in the different levels as exhibited by analyses of upland types. The content of calcium, on the whole, is much higher than that of magnesium in the surface soil, indicating a more abundant supply of calcium in the soil-forming materials. The calcium content remains the same or diminishes in the middle stratum as compared with the upper. This is accompanied by an increase in the magnesium content in both the middle and lower strata. These two elements are unequally removed from the soil by leaching, the calcium being dissolved and carried downward to a greater extent than magnesium. As they are carried downward in solution, magnesium is more readily reabsorbed by the soil mass than calcium, thus forcing more of the latter element out into the solution to be carried farther down. Consequently, while magnesium tends to accumulate in

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF OGLE COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES
Average pounds per acre in 2 million pounds of dry soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (600, 700, 900)							
626, 726, 926	Brown Silt Loam	49 210	5 000	1 120	840	33 060	7 080	9 830
726.5	Brown Silt Loam On Rock	43 520	5 100	1 100	860	31 460	9 080	11 180
760	Brown Sandy Loam	30 500	2 580	860	600	29 910	3 690	7 000
760.5	Brown Sandy Loam On Rock	34 030	3 050	1 010	460	32 230	4 260	5 310
728	Brown-Gray Silt Loam On Tight Clay	49 380	4 040	660	640	23 400	6 240	10 880
681	Dune Sand	15 640	1 220	780	260	29 760	1 620	3 040
690	Gravelly Loam[1]							
	Upland Timber Soils (600, 700)							
734	Yellow-Gray Silt Loam	30 410	3 120	860	490	32 650	6 560	10 230
735	Yellow Silt Loam	19 660	2 440	900	380	26 800	6 100	9 720
734.5	Yellow-Gray Silt Loam On Limestone	23 600	2 480	620	920	31 780	6 460	10 160
635.5	Yellow Silt Loam On Limestone	20 680	2 310	600	340	35 600	8 060	11 040
764	Yellow-Gray Sandy Loam	29 050	2 260	680	450	29 880	3 850	6 950
765	Yellow Sandy Loam	22 100	1 560	620	580	26 880	4 880	8 300
764.5	Yellow-Gray Sandy Loam On Limestone	25 690	2 050	730	330	25 760	3 620	6 390
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	60 740	5 770	1 260	890	32 090	4 550	8 690
1525	Black Silt Loam	113 570	12 990	2 380	1 750	27 220	13 860	54 630
1566	Brown Sandy Loam	24 760	1 600	600	340	27 300	2 200	3 440
1560.4	Brown Sandy Loam On Gravel	20 180	1 720	700	520	27 000	2 940	4 780
1561	Black Sandy Loam	90 160	8 000	1 520	1 220	35 900	9 060	21 580
1536	Yellow-Gray Silt Loam Over Gravel	25 370	2 610	860	590	30 590	4 130	7 610
1567	Yellow-Gray Sandy Loam Over Gravel	31 120	2 620	860	760	23 120	3 520	5 180
1564.4	Yellow-Gray Sandy Loam On Gravel	20 340	1 620	720	420	21 240	2 560	5 160
1528	Brown-Gray Silt Loam On Tight Clay	29 260	2 120	720	660	15 980	2 460	3 880
	Residual Soils (000)							
083	Residual Sand	28 340	1 680	620	520	3 060	1 620	1 140
098	Stony Loam[2]							
	Late Swamp and Bottom-Land Soils (1400)							
1450	Black Mixed Loam[3]							
1454	Mixed Loam[3]							
1401	Deep Peat[4]	287 460	31 880	1 740	3 550	4 290	6 730	25 280

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]Analyses not given because of uncertainty regarding the sample.

[2]Representative samples could not be taken because of the stony character of the soil.

[3]On account of the heterogeneous character of mixed loams, chemical analyses are not included for these types.

[4]Amounts reported are for 1 million pounds of Deep Peat.

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF OGLE COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
Average pounds per acre in 4 million pounds of dry soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (600, 700, 900)							
626, 726, 926	Brown Silt Loam	51 320	5 000	1 820	1 270	66 740	17 670	20 800
726.5	Brown Silt Loam On Rock	56 920	5 720	2 000	1 040	63 200	20 120	25 960
760	Brown Sandy Loam	44 690	4 390	1 590	970	64 200	8 550	15 190
760.5	Brown Sandy Loam On Rock	50 900	4 300	1 960	900	64 660	7 620	10 900
728	Brown-Gray Silt Loam On Tight Clay	38 520	3 400	1 360	920	49 760	15 920	19 760
681	Dune Sand	26 480	1 640	2 120	240	65 480	2 320	5 560
690	Gravelly Loam[1]							
	Upland Timber Soils (600, 700)							
734	Yellow-Gray Silt Loam	26 800	2 910	1 670	690	65 680	14 760	20 310
735	Yellow Silt Loam	20 840	1 920	1 800	800	59 000	10 000	20 200
734.5	Yellow-Gray Silt Loam On Limestone	26 840	2 280	1 320	1 200	58 520	16 760	18 520
635.5	Yellow Silt Loam On Limestone	29 600	2 760	1 400	600	68 320	75 960	198 360
764	Yellow-Gray Sandy Loam	25 960	2 050	1 110	520	55 570	10 660	13 370
765	Yellow Sandy Loam	25 400	3 600	1 560	960	54 120	14 200	13 840
764.5	Yellow-Gray Sandy Loam On Limestone	30 480	2 440	1 520	600	48 720	9 080	13 400
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	65 310	5 750	1 830	1 090	66 080	13 750	16 150
1525	Black Silt Loam	91 400	9 200	3 280	1 820	55 880	17 180	62 520
1566	Brown Sandy Loam	40 040	3 080	1 360	720	53 880	3 800	7 920
1560.4	Brown Sandy Loam On Gravel	29 080	2 400	1 320	680	52 600	7 520	10 000
1561	Black Sandy Loam	92 720	7 800	2 400	1 320	64 960	19 800	37 720
1536	Yellow-Gray Silt Loam Over Gravel	24 640	2 320	1 460	980	64 720	13 920	15 800
1567	Yellow-Gray Sandy Loam Over Gravel	29 440	2 200	1 520	1 080	44 800	10 680	10 000
1564.4	Yellow-Gray Sandy Loam On Gravel	23 200	2 160	1 560	600	53 320	6 800	9 560
1528	Brown-Gray Silt Loam On Tight Clay	24 360	1 680	1 000	880	31 080	6 360	7 560
	Residual Soils (000)							
083	Residual Sand	34 440	2 000	1 040	840	5 600	2 360	3 280
098	Stony Loam[1]							
	Late Swamp and Bottom-Land Soils (1400)							
1450	Black Mixed Loam[2]							
1454	Mixed Loam[2]							
1401	Deep Peat[3]	572 400	54 980	1 760	2 200	10 380	8 120	40 620

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Representative samples could not be taken because of the stony character of the soil.
[2]On account of the heterogeneous character of the mixed loams, chemical analyses are not reported for these types.
[3]Amounts reported are for 2 million pounds of Deep Peat.

the middle and lower strata, the liberated calcium, which is thus carried farther down than magnesium may accumulate at still great depths, or may be washed away entirely. These movements of calcium and magnesium, as indicated by the analyses of the different strata, constitute one factor in estimating the relative maturity of the various soil types.

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF OGLE COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES
Average pounds per acre in 6 million pounds of dry soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (600, 700, 900)							
626, 726, 926	Brown Silt Loam	35 380	3 880	2 930	1 310	97 780	38 220	48 630
726.5	Brown Silt Loam On Rock[1]	.....	.....	.....	.....	.....	.....	.....
760	Brown Sandy Loam	35 840	3 940	2 260	960	94 960	48 020	84 200
760.5	Brown Sandy Loam On Rock[1]	.....	.....	.....	.....	.....	.....	.....
728	Brown-Gray Silt Loam On Tight Clay	33 840	3 000	3 000	540	74 460	35 880	41 880
681	Dune Sand	28 740	780	1 800	780	95 220	5 520	9 540
690	Gravelly Loam[1]	.....	.....	.....	.....	.....	.....	.....
	Upland Timber Soils (600, 700)							
734	Yellow-Gray Silt Loam	29 400	3 090	3 270	980	96 200	30 260	47 430
735	Yellow Silt Loam	25 020	2 220	3 360	1 140	89 820	33 780	34 920
734.5	Yellow-Gray Silt Loam On Limestone	30 540	2 820	2 640	1 320	88 740	9 780	55 320
635.5	Yellow Silt Loam On Limestone[1]	.....	.....	.....	.....	.....	.....	.....
764	Yellow-Gray Sandy Loam	27 080	2 100	2 200	880	89 220	20 620	25 740
765	Yellow Sandy Loam	31 320	3 240	3 960	1 020	75 420	58 140	94 380
764.5	Yellow-Gray Sandy Loam On Limestone[1]	.....	.....	.....	.....	.....	.....	.....
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	35 540	3 260	2 900	1 100	98 560	28 500	28 540
1525	Black Silt Loam	37 320	3 840	3 960	1 200	83 730	44 040	60 330
1566	Brown Sandy Loam	27 960	2 160	1 320	780	78 420	4 800	9 180
1560.4	Brown Sandy Loam On Gravel	22 020	1 860	1 680	1 260	75 000	9 000	14 340
1561	Black Sandy Loam	23 810	2 520	2 640	900	98 340	68 880	133 560
1536	Yellow-Gray Silt Loam Over Gravel	27 150	2 490	2 940	1 200	99 300	32 550	36 090
1567	Yellow-Gray Sandy Loam Over Gravel	28 320	2 110	1 980	1 080	35 820	12 420	7 980
1564.4	Yellow-Gray Sandy Loam On Gravel	27 360	1 500	2 580	1 620	68 220	16 560	12 900
1528	Brown-Gray Silt Loam On Tight Clay	25 080	2 220	1 260	780	61 500	11 760	14 100
	Residual Soils (000)							
083	Residual Sand	.....	.....	.....	.....	.....	.....	.....
098	Stony Loam[1]	.....	.....	.....	.....	.....	.....	.....
	Late Swamp and Bottom-Land Soils (1400)							
1450	Black Mixed Loam[2]	.....	.....	.....	.....	.....	.....	.....
1454	Mixed Loam[2]	.....	.....	.....	.....	.....	.....	.....
1401	Deep Peat[3]	904 140	95 250	2 280	2 490	15 120	14 160	72 090

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Representative samples could not be taken because of the stony character of the soil.
[2]On account of the heterogeneous character of the mixed loams chemical analyses are not reported for these types.
[3]Amounts reported are for 3 million pounds of Deep Peat.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is not possible to obtain this information exactly, especially for the deeper-rooted crops, it seems probable that practically all of the feeding range of the roots of most of our common field crops

is included in the upper 40 inches of soil. By adding together for a given soil type the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

Studying the figures in this manner the tables reveal that there is not only a wide diversity among the different soils with respect to a given plant-food element, but that there is also a great variation with respect to the relative abundance of the various elements within a given soil type as measured by crop requirements. For example, in one of the most extensive soil types in the county, Brown Silt Loam, Upland, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 13,880 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus, 5,870 pounds, contained in the same soil is equivalent to that contained in 34,500 bushels of corn, while in the same quantity of this soil there is present 197,580 pounds of potassium, the equivalent of that contained in approximately 1 million bushels of corn. In marked contrast to this soil, with respect to nitrogen, is the Yellow-Gray Silt Loam, an important upland timber soil type, which contains in the 40-inch stratum approximately 9,120 pounds per acre of nitrogen, an amount equal to that in 9,120 bushels of corn. The phosphorus content is nearly as high as in Brown Silt Loam, namely, 5,800 pounds in an acre, which is equivalent to that contained in 34,100 bushels of corn. The potassium content of Yellow-Gray Silt Loam amounts to 194,530 pounds.

With respect to calcium it is not feasible to make such comparisons in soil types which differ within themselves as to the presence or absence of native calcium carbonate (limestone). In such soils the average calcium content cannot be taken as representative of the type. For example, one sample of Yellow-Gray Silt Loam is acid thruout the entire 40-inch depth, the carbonates having been leached to a greater depth than 40 inches. Another sample of the same type contains carbonates in the lower stratum (20 to 40 inches) and consequently is non-acid. The acid sample contains 26,940 pounds per acre of calcium in the lower stratum while the other has 95,640 pounds, or more than three times as much. These differences are thus much greater than the variations between averages of different soil types.

The above statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration aside from merely the amount of plant-food elements present. Much depends upon the nature of the crops to be grown as to their utilization of plant-food materials, and much depends upon the condition of the plant-food substances themselves, as to their availability. Finally, in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such chemical data do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon, and in this way contribute fundamental information for the intelligent planning, in a broad way, of systems of soil management for conserving and improving the fertility of the land.

DESCRIPTION OF SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Ogle county occupy 433.30 square miles, or 57.46 percent of the area of the county. They are fairly well distributed over the county with the exception of the territory adjacent to Rock river, which is occupied by timber soils.

The dark color of the prairie soils is due to the accumulation of organic matter, which is derived very largely from the fibrous roots of the prairie grasses. The network of grass roots was protected from rapid and complete decay thru the partial exclusion of oxygen by the covering of fine, moist soil and mat of vegetative material consisting of old grass stems and leaves. The stems and leaves were burned in part by prairie fires or disappeared in part by decay. Thus they added but little organic matter to the soil directly, but, being constantly renewed, they helped to check the decay of the fibrous roots.

Brown Silt Loam (626, 726, 926)

Brown Silt Loam is the most extensive of the upland types in Ogle county. It covers an area of 384.24 square miles, or just about one-half of the area of the county.

This type shows some variation in the different parts of the county with reference to the depth of horizons, color, texture, and topography. Its topography varies from undulating to rolling. The southeastern corner of the county, which is morainal, and the north and west portions are rolling. The remainder of the Brown Silt Loam is undulating to slightly rolling in topography.

Drainage in this type is well developed. The depth to the glacial till varies in the different parts of the county. The underlying material thruout the type is glacial drift, with the exception of the areas where no till was deposited or where it has been eroded away, in which cases the soil has developed directly on the bed rock. The thickness of the surface loess, or loess-like material, varies from about 20 inches to as much as 6 feet. These differences in depth and associated differences in soils are not shown on the soil map. Brown Silt Loam adjacent to Sandy Loam is more or less of a sandy texture. Practically all of the type is under cultivation.

The A_1 horizon, which is about 7 inches thick, is a light to medium brown silt loam, having an appreciable amount of sand present near the sandy areas. The A_2 horizon, extending to a depth of about 18 inches, is friable in texture and varies from a light brown silt loam with a slight yellow cast to a yellowish brown silt loam. The yellowish shade occurs on the more rolling areas. The B horizon is about 20 inches in thickness and is a slightly compact yellow silt loam with slight joint mottling. Below a depth of 24 to 38 inches the C horizon occurs. This is a friable yellow silt loam, somewhat mottled in the joints and splotched with yellow and red iron concretions.

The type shows the same character of profile on the areas where the till lies within 20 inches or so of the surface, with the exception that the surface, subsurface, and subsoil horizons are not so thick as where the till is deeper.

Management.—For suggestions regarding the management of this soil, the reader is referred to the results of experiment fields at Mt. Morris and at Dixon, pages 47 and 54, which may be considered as fairly representative of most of the Brown Silt Loam as it occurs in Ogle county. It will be noted that manure has given excellent returns on these fields and that the use of limestone has paid a fairly good profit. The use of rock phosphate has resulted in crop increases just about sufficient to pay for the application of one-half ton of this material per acre once in four years. The reader is referred to page 39 for a further discussion of the phosphate problem.

Present knowledge regarding the management of this soil, while not complete, indicates clearly the need for fresh organic matter, and, on a considerable portion of the type, an application of limestone. The amount of limestone needed varies and should be determined for each field. The clovers, or other legumes, should be regularly grown to supply fresh organic matter and also nitrogen. At the same time this is being done, trials may well be made of the various phosphates including rock phosphate, basic slag, steamed bone meal, and acid phosphate. It should be borne in mind in making these trials that, of the grain crops, wheat responds best to phosphate.

Brown Silt Loam On Limestone (626.5, 726.5)

Brown Silt Loam On Limestone occurs in small scattering areas thruout most of the county, occupying a total of 1.38 square miles. This type is usually located on the slopes of the more rolling areas of prairie soil where the limestone occurs within 30 inches of the surface. Only a very general description of the soil horizons can be written because the depth to the rock varies from a few inches to about 30 inches.

The A_1 horizon, with an average depth of 6 inches, is a brown silt loam. The A_2 horizon, extending to a depth of about 18 inches, is a light brown to a yellowish brown silt loam. The B horizon extends to the bed rock which occurs at variable depths as stated above. This horizon occurs in two parts. The upper part is a slightly compact yellow silt loam; the lower is a compact, red, residual clay from 2 to 4 inches in thickness resting directly on the limestone.

Management.—This type is suitable only for pasture because of its drouthy nature. It produces excellent bluegrass and, with the exception of the shallower portions, should grow good sweet clover.

Brown Sandy Loam (760)

Brown Sandy Loam occurs east of Rock river, in the regions of the glacial fills of the old preglacial stream valleys, and also adjacent to Rock river. The sandy texture of the soil is due to wind action which has blown the sand out of the bottoms upon the uplands. The topography of the type is undulating to rolling. The drainage is usually well developed, owing to the open subsoil.

The A_1 horizon, extending to a depth of about 8 inches, is a brown sandy loam. The A_2 horizon which extends to a depth of about 18 inches, is a light brown to yellowish brown sandy loam. The upper 8 or 9 inches of the B horizon

varies from a friable, yellow sandy loam, splotched with gray, to a slightly compact, yellow clayey sand. The C horizon is a yellow, sandy, gravelly loam. It occurs at a depth of 25 to 35 inches.

Management.—Brown Sandy Loam is somewhat acid, tho it varies in degree of acidity. It has a slight tendency to be drouthy in places where the soil is shallow, and in some areas considerable trouble is caused by its drifting with the wind.

The general recommendations for the management of this type include the application of limestone at the proper rate, the growing and turning down of legumes, preferably sweet clover, and the use of early maturing crops on the drouthy areas. The proper rate of application of limestone can be determined by the County Farm Adviser or by securing the assistance of the Agricultural Experiment Station. Alfalfa will do well on this soil after sufficient limestone has been applied, particularly if it is preceded by sweet clover.

Brown Sandy Loam On Limestone (660.5)

Brown Sandy Loam On Limestone, which occupies only 1.64 square miles, or .22 percent of the area of the county, occurs in scattering areas along the east side of Rock river. Usually, these areas are rather indefinite as to outline because of the irregularity in the contours of the limestone beds. Most of the areas have been left in permanent pasture, because the rock is too near the surface for cropping. The topography is slightly rolling, permitting good drainage. The limestone lies at depths varying from a few inches to 30 inches below the surface, the most common depth being 8 to 20 inches.

The A_1 horizon, varying from 4 to 7 inches in thickness, is a brown sandy loam. The A_2 horizon is a light brown sandy loam. The B horizon, which varies from 4 to 6 inches in thickness, lies directly on the limestone and is either a compact, reddish yellow, gravelly, sandy clay, or a red clay.

Management.—This type is better adapted to permanent pasture than to the general farm crops. Its occurrence, however, as small scattering areas in the Brown Sandy Loam makes it necessary to farm many of the areas in the same way that the latter type is farmed. General suggestions for the management of Brown Sandy Loam may be found on page 16.

Brown Sandy Loam On Sandstone (760.5)

Brown Sandy Loam On Sandstone, which occupies a total of only 64 acres, occurs south of Oregon. The topography of the region in which the small areas of this type occur is undulating to rolling. Drainage is well developed, owing to the slope and to the open nature of the soil.

This type may be thought of as poor spots in Brown Sandy Loam. For this reason it usually is not practical to give it any special management.

Brown-Gray Silt Loam On Tight Clay (628, 728)

Only 25 acres of Brown-Gray Silt Loam On Tight Clay, Upland, occur in Ogle county.

The A_1 horizon is a grayish brown silt loam. The A_2 horizon is a gray silt loam, and the B horizon is a tough, plastic, compact, drab clay.

Management.—The small area of this type in Ogle county makes its management of no general interest. Suggestions may be secured from the Agricultural Experiment Station by anyone interested.

Dune Sand (781)

Dune Sand, Upland, comprizes a total of 2.11 square miles in Ogle county. It occurs in the areas of sandy loams where the wind has had opportunity to rework the sand particles and has redeposited them in dune-like formations. Blowouts, as well as dunes, are common in the region. The topography of the type is billowy.

The A_1 horizon, which varies from 0 to 3 inches in thickness, depending on the amount of organic matter that has accumulated, is a brownish yellow to yellow, loamy sand. There is no distinct horizon development below this shallow, brownish surface, the material below consisting of yellow sand.

Management.—Dune Sand is somewhat acid and the correction of this condition by the use of limestone is the first step towards the profitable utilization of this type. The Oquawka experiment field is located on Dune Sand and very striking results have been secured there with limestone and manure and with limestone and sweet clover. The reader is referred to page 58, where the crop yields on this field are given. The information given by these figures is the best available for Dune Sand, either Terrace or Upland, as it occurs in Ogle county.

Gravelly Loam (690, 790)

Gravelly Loam occupies a total area of only a little more than 1½ square miles. It occurs in the localities where eskers, or gravelly ridges, have been built by subglacial streams or in crevices of the ice mass. Very little loessial material occurs on these gravel ridges. The three main areas of Gravelly Loam are the Adeline, Hazelhurst, and Stillman Valley eskers. They are of very little agricultural value aside from pasture. The gravels are used for road building and railroad fills.

(b) UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along streams and on or near somewhat steep morainal ridges. Their most noticeable characteristic is the yellowish gray color of the surface, due in part to its low organic-matter content. The deficiency in organic matter has been caused by the long-continued growth of forest trees. Two effects were produced by the forest trees: the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large organic-matter content in prairie soils; and the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed completely or were burned by forest fires. As a result, the organic-matter content of the upland timber soils is always less than that of the adjacent prairie land. Several generations of trees were necessary to produce the present condition of the soil.

The upland timber soils occupy 154.76 square miles, or practically one-fifth of the area of the county.

Yellow-Gray Silt Loam (634, 734, 934)

The total area of Yellow-Gray Silt Loam in Ogle county is 118.46 square miles, or 15.70 percent of the area of the county and approximately 75 percent of the total area of the timber soils. It occupies the portion of the light-colored or timber soil area of the county which has an undulating to slightly rolling topography. In the northwestern part of the county certain areas have been classified as Yellow-Gray Silt Loam in which the light color of the soil is the result of erosion rather than of forest growth. These areas altho not strictly of the type Yellow-Gray Silt Loam, are correlated with it because of their small total extent.

The A_1 horizon, which is about 6 inches in thickness, is a brownish yellow to a grayish yellow silt loam. The A_2 horizon, extending to a depth of about 18 inches, is a yellow silt loam mottled with gray. The B horizon, extending to about 32 inches in depth, is a slightly mottled, slightly compact, yellow silt loam. The C horizon, below 32 inches, is a friable, strongly mottled, yellow silt loam splotched with brown and red iron concretions.

Management.—Yellow-Gray Silt Loam is slightly acid and is low in nitrogen and organic matter. The application of about 2 tons of limestone an acre and the growing of sweet clover are recommended as effective treatments in rapidly increasing the productivity of this soil. The sweet clover can be used to advantage by pasturing it in the fall of the first year and plowing it down for corn in the spring of the second year. If wheat is grown, it is suggested that a trial be made of one or more of the following carriers of phosphorus: acid phosphate applied at the rate of about 300 pounds an acre, steamed bone meal at half the above rate, basic slag applied at the rate of about 200 pounds an acre, or rock phosphate applied at the rate of about 1,000 pounds an acre. There are no experiment field results exactly applicable to this soil type as it occurs in Ogle county, but the very striking increases in yield obtained with steamed bone meal as well as with rock phosphate, on a somewhat similar soil in Lake county, leads to the suggestion that some form of phosphate be given thoro trial.

Yellow Silt Loam (635, 735)

Yellow Silt Loam occurs in irregular areas as rough and broken land immediately adjacent to streams and on slopes at some distance from the streams. As mapped, it is the eroded portion of the timber soils from which much or all of the surface soil has been removed by washing, exposing a yellow subsoil. Yellow Silt Loam covers 17.39 square miles, or 2.30 percent of the area of the county. The exact character of this type varies greatly because of differences in vegetation and the amount of washing.

The A_1 horizon, which may extend to a depth of 3 or 4 inches, is usually a grayish yellow to a brownish yellow silt loam. Below this depth, a friable yellow silt loam may occur, which rests on a medium plastic, rather compact, yellow

silty clay loam. Till and limestone rock vary in depth below the surface, depending on the amount of erosion that has taken place. Usually the depth to till or rock varies from 25 or 30 inches to 4 or 5 feet. A stratum of yellowish red, sandy clay loam, 4 to 8 inches in thickness, frequently occurs directly above the limestone.

Management.—The timber has been cut off from practically all of the land included in this type. Certain areas of the type near Rock river have grown up in underbrush and scrub timber and are of no value as sources of timber and of little value as pasture. Other areas have been farmed with disastrous results because of erosion. The less steep slopes may be farmed successfully but special precautions must be taken to reduce erosion. The wisest course to follow with this land is to put the steepest slopes in timber and the less steep slopes in orchard or permanent pasture. Results of some experiments on this type as it occurs in southern Illinois is given in the account of the Vienna field, found on page 55.

Yellow-Gray Silt Loam On Limestone (634.5, 734.5)

Yellow-Gray Silt Loam On Limestone occupies a total area of less than one square mile. It occurs as small areas thruout Yellow-Gray Silt Loam.

The A_1 horizon, which is about 5 or 6 inches in thickness, is a grayish yellow silt loam. The A_2 horizon, extending to about 14 inches in depth, is a yellow silt loam mottled with gray. The B horizon, which is made up of two distinct strata, extends to the bed rock. The upper portion is a compact, slightly mottled, yellow silty clay loam. It rests on a layer of sticky, compact, reddish yellow to red residual clay about 3 or 4 inches in thickness. This red clay rests directly upon the limestone which lies 20 to 30 inches below the surface.

Management.—Since this type is so intimately associated with Yellow-Gray Silt Loam, it must in most cases receive the same management as Yellow-Gray Silt Loam. The reader is referred to the discussion of the latter type on page 19.

Yellow Silt Loam On Limestone (635.5, 735.5)

Yellow Silt Loam On Limestone occupies the same topographic position as Yellow Silt Loam. It covers only .89 of a square mile and is usually found on the steepest slopes. The type is non-agricultural, owing to the nearness of the limestone to the surface and the steepness of its topography. The depth to limestone varies from a few inches to as much as 30 inches below the surface.

The A_1 horizon is usually about 2 or 3 inches in thickness and varies from a dark brown or brownish yellow to a grayish yellow silt loam. Below this depth a stratum of yellow silt loam occurs which is usually about 6 inches in thickness. As the underlying limestone is approached, the material becomes a plastic, sandy to gravelly, yellow clay loam, with a stratum of red, residual clay immediately on top of the limestone.

Management.—This type can be used in most cases only for timber or pasture.

Yellow-Gray Sandy Loam (664, 764)

Yellow-Gray Sandy Loam occurs near Rock river, where a considerable amount of sand has been blown from the bottom land and deposited on the upland by the winds. It occupies 14.77 square miles, or 1.95 percent of the area of the county. The topography of the type varies from undulating to rolling. Drainage is good because of the open sandy subsoil.

The A_1 horizon, which is about 5 inches in thickness, is a grayish yellow sandy loam. The A_2 horizon, extending to a depth of about 15 inches, is a yellow sandy loam with slight joint mottling. The B horizon, in the upper portion, is a slightly compact, yellow, sandy silt loam. In the lower portion it is a yellow sand at about 24 or 25 inches. At about 32 inches a gravelly glacial till occurs, which may rest on limestone bed rock within 35 or 40 inches of the surface.

Management.—A portion of this type remains in timber and some of it is in permanent pasture. Both the nitrogen and organic-matter contents of the soil are low and an application of about 2 tons of limestone an acre must be made before sweet clover or alfalfa can be grown. The open nature of the subsoil makes this type somewhat drouthy, and for that reason it is advisable to grow early maturing crops. Provision should be made in the cropping system for the regular addition of leguminous green manure to the soil. No mineral fertilizer treatment is advised for this type except on a small trial basis.

Yellow Sandy Loam (665, 765)

Yellow Sandy Loam occurs as eroded areas in the same region as Yellow-Gray Sandy Loam. It is also found on some of the steep slopes of the Residual Sand areas. It occupies a total of only 1.72 square miles, and only areas of small acreage are to be found, most of which are near Rock river.

This soil to a depth of 2 to 5 inches is a brownish yellow to yellow sandy loam. No distinct A_2, B, or C horizons are distinguishable because of the fact that this soil is immature, owing to rapid erosion. For a depth of 15 to 18 inches it is usually a yellow sandy loam, and below this depth a yellow to reddish yellow, sandy clay loam occurs. The reddish color usually occurs in a stratum 6 to 8 inches thick, which lies directly above the sandstone or limestone.

Management.—Yellow Sandy Loam is, for the most part, kept in pasture and timber and this practice should be continued.

Yellow-Gray Sandy Loam On Limestone (664.5)

Yellow-Gray Sandy Loam On Limestone occurs in small, scattering areas thruout the limestone region along Rock river. It covers a total of only .09 of a square mile. This type is very similar to Yellow-Gray Silt Loam with the exception that the underlying limestone occurs at a depth of 12 to 28 or 30 inches below the surface. It is of very little importance and should be handled in the same way as Yellow-Gray Sandy Loam (see management discussion above).

Yellow-Gray Sandy Loam On Sandstone (764.5)

Yellow-Gray Sandy Loam On Sandstone occurs in scattering areas in the sandstone region. It occupies a total of only .63 of a square mile. Most of the type is utilized for pasture land because the sandstone is too near the surface for good farm land. It is of even less value than Yellow-Gray Sandy Loam On Limestone and no effort should be made to put it in cultivated crops.

(c) TERRACE SOILS

Nearly all of the terrace soils are located in the eastern part of the county along the course occupied by the preglacial Rock river. In addition to this large terrace Rock river has constructed small sand and gravel terraces along its present course, and some small terraces are found along the small streams.

These terraces were formed by streams overloaded with sediment during flood periods. Later when the streams diminished in volume, these former flood plains were no longer overflowed and became terraces. At the same time new flood plains at lower levels were formed.

Brown Silt Loam Over Gravel (1527)

Nearly all the areas of Brown Silt Loam Over Gravel are found in the eastern part of the county, in the preglacial Rock river terrace. Some small areas occur along Rock river and its tributaries. The type occupies 51.7 square miles, or 6.85 percent of the area of the county. In topography it varies from flat to undulating. Drainage has, for the most part, been well established thru the construction of dredges and lateral tiling. In the southern part of the county near Rochelle the type is a heavier phase and needs better drainage than is at present provided.

The A_1 horizon, which is about 8 inches thick, is a brown to dark brown silt loam. The A_2 horizon, extending to a depth of about 18 inches, is a yellowish brown silt loam. The B horizon occurs as a stratum about 12 inches in thickness. It varies from a slightly plastic, fairly compact, silty clay to silt loam. It is usually drabbish gray in color. The C horizon occurs below 30 inches. It is a friable, mottled, yellow silt loam splotched with orange-red concretions. The depth to sand and gravel varies from 42 to 50 inches below the surface.

Management.—This type varies in acidity and each field should be tested before applying limestone. The reader is referred to the discussion of Brown Silt Loam, Upland, page 15, for suggestions regarding the management of this terrace type.

Black Silt Loam (1525)

Black Silt Loam is second in extent of the terrace types, occupying 16.11 square miles. It is found in scattered areas thruout the preglacial Rock river terrace and occupies the low-lying, flat land. The transition from Brown Silt Loam to Black Silt Loam is very gradual.

The A_1 horizon, which is about 6 inches thick, varies from black silt loam to black silty clay loam, with a slight gray cast in areas which are alkaline. The A_2 horizon, which extends to a depth of about 17 inches, is a plastic, black clay

loam. The B horizon in the upper 14 inches is a plastic, compact, drab clay loam, splotched with yellow and gray streaks. The lower part of the B horizon, extending to about 40 inches in depth, varies from a plastic, drab to gray, silty clay loam. Below 40 inches it changes to a friable material which rests on a substratum of yellow to gray sand at a depth of about 48 inches.

Management.—The drainage of the low-lying, flat land occupied by this type has been fairly well taken care of by dredge ditches and tile, altho portions of the type need additional drainage. Alkali is common thruout the type and occurs in harmful amounts in some places. Its bad effects may be counteracted by the use of about 100 pounds of a potash salt per acre. The organic-matter content of this soil is high, but it should not be cropped continuously without the addition of fresh organic matter at regular intervals in the rotation. The practice has become common of raising a crop of sweet corn on this land followed the same year by a crop of peas. This practice gives a high return, but if continued on the same land year after year, it would not provide for returning sufficient organic matter to the soil.

Brown Sandy Loam Over Gravel (1566)

Brown Sandy Loam Over Gravel is found in scattered areas thruout the different terrace formations of the county; most of it, however, occurs along Rock river, and Stillman and Kyte creeks. The topography of the type varies from undulating to rolling. Drainage is good because the type is underlain with sand and gravel. It occupies 7.32 square miles, or .97 percent of the area of the county. Practically all of the type is under cultivation, altho some of it in the vicinity of Daysville and Honey Creek is left in pasture because of the low organic-matter content and the high percent of sand.

The A_1 horizon, extending to about 8 inches in depth, is a medium to coarse-grained brown sandy loam. The A_2 horizon, which extends to a depth of about 18 inches, is a yellowish brown to yellow sand. The B horizon, in the upper 6 or 7 inches, is a slightly plastic, somewhat compact, yellow, sandy clay loam, slightly mottled and splotched with brown iron concretions. Below 28 inches, it is a yellow sand, strongly splotched with red iron concretions. About 38 to 45 inches below the surface, the sand contains a considerable amount of small pebbles.

Management.—As a general rule the drainage of the undulating phase is fair, but in the flat areas near Daysville, artificial drainage is necessary. Some difficulty is encountered in the case of open ditches which tend to fill up rapidly with sediment. This soil will respond well to good farming, including the application of limestone and the turning down of nitrogenous organic matter. It is a good alfalfa soil and produces good corn following sweet clover or alfalfa.

Brown Sandy Loam On Gravel (1560.4)

Brown Sandy Loam On Gravel occurs along the old preglacial Stillman creek in the vicinity of Stillman Valley and a few scattering areas along Rock river. It covers a total area of only 1.81 square miles. The topography is undulating and the drainage is well developed since there is plenty of fall to the

streams and the substratum is open. The nearness of the gravel to the surface has a detrimental effect upon growing crops during seasons of drouth.

The A_1 horizon, extending to a depth of 8 inches, is a medium to coarse-grained brown sandy loam. The A_2 horizon, which extends to about 21 inches in depth, is a yellowish brown sand. Since the depth to the underlying gravel varies from 22 to 34 inches, depending on the contour of the gravel bed, the B horizon is variable in depth and texture. On an average it is 6 or 7 inches in thickness and is a slightly compact, yellow clayey sand, with some fine gravel, resting on gravelly sand, directly above the gravel deposits.

Management.—The fact that the stratum of soil above the gravel is rather thin accounts for the drouthy nature of this type. Since the soil is low in nitrogen and organic matter, the growing of legumes is advised. With the tendency of the type to be slightly acid, an application of about 2 tons of limestone is advisable. Also, the use of early maturing crops is recommended because for such crops the period of greatest need of moisture is past before the driest part of the season approaches.

Black Sandy Loam (1561)

Black Sandy Loam is located in the terraces of Kishwaukee river in the northeast part of the county. It occupies only about 160 acres. It is flat in topography and has been fairly well drained of late years. It is slightly lower in elevation than the adjoining types.

The A_1 horizon, which is about 6 inches thick, is a black sandy loam, with some silty and clayey spots too small to show on the map. The A_2 horizon, extending to a depth of about 17 inches, is a brown to black sandy loam. The B horizon in the upper 7 inches is a drab sandy loam, becoming a clayey sand at about 24 inches. Below this depth it is a slightly compact, sandy clay loam, drabbish yellow to yellow in color, which passes into a yellow sand at depths varying from 36 to 45 inches below the surface.

Management.—The improvement of the underdrainage is the first problem in the management of this type in order to lower the water table and remove the alkali which occurs in spots. These spots can be made productive by applying potassium salts at the rate of about 100 pounds an acre. Plowing down manure and straw also helps in overcoming the bad effects of the alkali. Legumes should have a regular place in the rotation as a source of nitrogen and readily decomposable organic matter, particularly for the non-alkali portions of the type.

Yellow-Gray Silt Loam Over Gravel (1536)

Yellow-Gray Silt Loam Over Gravel occurs in scattered areas thruout the terraces, particularly along Rock river and its tributaries. The type occupies a total of 8.69 square miles. Its topography is undulating and the drainage is fairly well established, altho there are small depressions of a heavier soil, rather poorly drained, scattered thruout the areas.

The A_1 horizon, which is about 6 inches in thickness, is a friable brownish yellow or grayish yellow silt loam. The A_2 horizon, extending to a depth of about 18 inches, is a friable, mottled, yellow silt loam. The B horizon in its upper

18 inches is a plastic, compact, slightly mottled, yellow silty clay loam which changes to a plastic, compact, golden yellow silt loam at about 42 inches. This lower stratum rests on the gravel which is calcareous and well stratified.

Management.—The management requirements of this type are the same as for Yellow-Gray Silt Loam, Upland (see page 19).

Yellow-Gray Sandy Loam Over Gravel (1567)

Yellow-Gray Sandy Loam Over Gravel occurs in small areas thruout the terraces of Rock river and some of the preglacial stream formations. It occupies a total area of only 2.19 square miles. It is undulating in topography. Because of the closeness of the gravel beds to the surface, the type is well drained and yet at the same time it is not drouthy.

The A_1 horizon, which is about 7 inches thick, varies from a yellowish brown to a grayish yellow sandy loam. The A_2 horizon, which extends to a depth of about 15 inches, is a slightly mottled, yellow sandy loam. The B horizon to a depth of about 22 inches is a fairly compact, yellow sandy clay loam. Below 22 inches it is a yellow sand with sand and gravel beds occurring at about 36 inches.

Management.—This type should be managed in the same way as Yellow-Gray Sandy Loam, Upland.

Yellow-Gray Sandy Loam On Gravel (1564.4)

Yellow-Gray Sandy Loam On Gravel occupies only .46 of a square mile. Nearly all of the areas occur along Rock river and in the pre-glacial Leaf river between Rock river and the village of Stillman Valley. The topography is undulating. Drainage is practically all vertical thru the gravel deposits. The gravel is so near the surface that the growing crops are affected during seasons of drouth.

The A_1 horizon, which is approximately 4 inches in thickness is a medium to coarse-grained, grayish yellow sandy loam. The A_2 horizon, extending to about 17 inches in depth, is a mottled, yellow sandy loam or yellow sand. The B horizon in its upper 7 inches is a fairly compact, yellow clayey sand which rests on gravelly yellow sand.

Management.—The management of this type is about the same as for Brown Sandy Loam On Gravel (1560.4). Since the type is low in organic matter and nitrogen, legumes should be grown wherever it is possible in the rotation. An application of about 2 tons of limestone an acre will aid the growth of legumes.

Dune Sand (1581)

Sand dunes occur in scattered areas thruout the terraces of the county associated with the sandy loam types. The dune formations are the result of wind action which has reworked the sand and deposited it in ridges. Near Oregon some of the sand dunes have had large blowouts formed in them. Some of the low-lying areas of sand are not true dune formations. This type in the terrace covers 1.07 square miles, or .14 percent of the area of the county. Drainage is rapid because of seepage thru the open substrata, often causing mucky and

peaty spots adjacent to the dunes. However, most of these peaty spots are too small to be shown on the map.

The A_1 horizon varies from 0 to 3 inches in thickness, depending on the amount of organic matter that has accumulated. It varies in color from a light brown to yellow sand. Below this horizon the material is uniformly a yellow sand to a depth of 4 feet or more.

Management.—Most of the Dune Sand, Terrace, is not used for farming. Its use for cropping presents peculiar difficulties. The reader is referred to the discussion of Dune Sand, Upland, page 18.

Brown-Gray Silt Loam On Tight Clay (1528)

Brown-Gray Silt Loam On Tight Clay, Terrace, occupies only 32 acres. It is flat in topography and is poorly drained, owing to the compact, plastic clay layer which is almost impervious to the movement of water. Suggestions regarding its management may be secured from the Agricultural Experiment Station.

Brown-Gray Sandy Loam On Tight Clay (1568)

Brown-Gray Sandy Loam On Tight Clay occupies only about 32 acres. It occurs in Section 13, Township 22 North, Range 11 East. It is poorly drained owing to the compact subsoil and the seepage water which it receives. Most of this type is left in pasture.

(d) RESIDUAL SOILS

Residual soils are formed from the residue left in place from the weathering of the rock and by the accumulation of organic matter. Most of the residual soil areas are located along the present valley of Rock river and some of the preglacial valleys of small streams, where the former streams, as well as erosion, have swept all the glacial material from the rock and left it exposed.

Sand (083)

Residual Sand occurs along Rock river from Oregon to Grand Detour. Very few areas of this type occur at any great distance from Rock River. Along the north shore of the preglacial Kyte creek and north of Brookville some outcrops of sandstone occur. The topography of the type is rough to broken. It is non-agricultural except for some pasture. Some of the sand is being quarried for use in glass manufacturing. A characteristic of the sandstone bedrock is that it weathers and crumbles readily when exposed. The residual sand is gray or white, except where organic matter from the rotting leaf mold is incorporated in the upper part, forming a brown color to a depth of 1 or 2 inches. The type occupies about 3 square miles of the county.

Management.—Pasture and permanent forestry are apparently the only ways in which this type can be utilized other than as a source for sand for industrial uses.

Stony Loam, Limestone (098)

Stony Loam, Limestone, occurs principally on the eroded slopes which are underlain with limestone near the surface. The stones vary in size from gravel

to 6 or 8 inches in diameter. They are mixed with some soil material which may be either silty or sandy. The type occupies 3.62 square miles, or .47 percent of the area of the county. The only agricultural value of the type is for pasture and timber land.

Stony Loam, Sandstone (098)

Stony Loam, Sandstone, occurs in the region of the St. Peter's sandstone on the eroded slopes where the weathering processes have disintegrated the sandstone to form broken pieces varying in diameter from 2 to 10 or 12 inches, mixed with sand. The type is of no agricultural value, even for pasturing purposes.

Limestone Outcrop (099)

Limestone Outcrop, which occupies altogether 198 acres, is found along Rock river and some of the small streams. The rock exposures vary in height from 20 to 125 or 150 feet. It is non-agricultural, aside from its value as a source of crushed limestone. In some localities, beyond hauling distance from shipping points, portable limestone crushers have been set up, thus furnishing neighboring farmers with ground limestone for agricultural use. There are numerous local quarry sites well distributed over the county.

Sandstone Outcrop (099)

Sandstone as an outcrop occupies only 51 acres. It is non-agricultural in value. The only interest in these areas lies in their scenic beauty.

(e) LATE SWAMP AND BOTTOM-LAND SOILS

This group includes the bottom lands along streams, the swamps, and the poorly drained lowlands. Much of the soil, therefore, is of alluvial formation and is largely subject to overflow. Overflow occurs, however, only during periods of excessive rains, and soon subsides.

The swamps occupy the low marshy areas in the preglacial Rock river terrace and some of the preglacial valleys formed by its tributaries. They also occupy the depressions in the upland that are often the sources of intermittent streams.

This group includes only three soil types which occupy a total area of 64.52 square miles, or 8.56 percent of the area of the county.

Black Mixed Loam (1450)

Black Mixed Loam occupies 21.06 square miles, or 2.80 percent of the area of the county. The largest areas are located in the eastern part of the county in what is known as the preglacial Rock river terrace. The other areas are scattered thruout the upland, usually occurring as depressions in the undulating or rolling upland in which many of the small, intermittent streams find their sources. Much seepage and drainage water reaches these areas, thus providing optimum conditions for the accumulation of organic matter. Usually, the streams which flow thru these areas have no well-defined channels and remain sluggish thru lack of sufficient fall. However, in the larger areas, drainage is better established

thru the construction of dredges and the installation of tile. As the name indicates, Black Mixed Loam is black in color, and is made up of a number of types which would be shown on the map if they occurred in larger areas.

The A_1 horizon varies from a peaty loam or muck to a silt or sandy loam, brown to black in color. This horizon is rich in nitrogen and organic matter. The A_2 horizon is usually a black clay loam. The B horizon is a fairly compact, plastic but pervious drab clay loam, which has some streaks of yellow at a depth of 36 to 40 inches.

Management.—The first important factor in management of this type is good drainage, which is frequently difficult to obtain because of the lack of an outlet. The soil is very productive, tho it is alkaline in some spots. Good drainage and the application of potash salts, manure, and straw will counteract the ill effects of the alkali. The installation of drainage has opened up many areas of this type for cultivation which were, until recently, used only for pasture.

Mixed Loam (1454)

Mixed Loam occurs as bottom land along Rock river as well as the small streams thruout the county. It usually takes the form of narrow strips rarely more than a quarter of a mile in width. The type occupies 43.08 square miles, or 5.71 percent of the area of the county. As the name indicates, this type is made up of a number of types, the areas of which are too small to be shown on the map. In texture it may be a silt loam, sandy loam, loam, or sand. In color it varies from a grayish yellow or yellow to a brown or black. Even if it were possible to indicate these different variations on the map, the first flood would probably leave a different mixture of soil material. For this reason it is impossible to write a detailed description which will apply to the type as a whole.

Management.—Practically all of this type is subject to overflow. The sediment deposited at each flood maintains a good supply of the elements of plant food. Since there is danger of this type being flooded at any time, the general practice is to keep it in pasture instead of growing cultivated crops on it.

Deep Peat (1401)

Deep Peat occupies only .38 of a square mile in Ogle county. The deposits occur in scattered areas, none of which are large and most of which are poorly drained.

To a depth of about 8 inches the type is a well-decomposed peat with its fibrous structure destroyed. Below this depth some fibrous material occurs. The proportion of fibrous material increases with increasing depth until the plastic, fairly compact, drab to black clay loam, which underlies the peat at a depth of about 40 inches, is reached.

Management.—Very little effort has been made to farm the peat deposits in Ogle county because they are swampy and difficult to drain. The peat bogs in the pastures have many hummocks varying from 4 to 12 inches or more in height. Some areas have been put under cultivation, and, with an application of potassium salts, produce fair yields.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items, such as native vegetation (whether timber or prairie), topography, and geological origin and formation, may assist in the differentiation of types, altho they are not fundamental to it.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a matured soil, three horizons designated as A, B, and C are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the A horizon.

C designates the layer lying below the B horizon and in which the material has been less affected by the weathering processes.

Frequently differences within a stratum or zone are discernible, in which case it is subdivided and described under such designations as A_1 and A_2, B_1 and B_2, etc.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in differentiating soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of this Report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state

800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* formed by material derived from the Illinoisan or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged Glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data beginning on page 7.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, crop-

ping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain...	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw...	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain....	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover....	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs.....	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.....	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oats straw.....	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed....	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay....	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed ..	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay...	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay....	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1] See footnote to Table 5.

[2] Young second-year growth ready to plow under as green manure.

[3] Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning

recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4_1 have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.

1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, acid phosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate, and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as

sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average livestock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached

out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of

crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before

ne crop is planted. Whether the crop be corn
f the season is dry, much damage may be done.
poor stand is likely to result and if put in oats,
nfavorable for their growth. Sometimes the soil is
also produces a partial puddling which
biological processes. The effect becomes worse
organic matter below the amount necessary to

Systems of Crop

In a program of permanent soil impro
a good rotation of crops, including, for the
use of legumes. No one can say in advance
prove to be the best rotation of crops, because of
and in prices for produce. As a general principle
the frequent introduction of leguminous crops.
ng up poor soils.

Following are a few suggested rotations
lines to be modified according to special circ

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats with clover, or
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and
Sixth year —Clover, or clover and grass

In grain farming, with small grain grown
the unsalable products should be returned to the
clipped and left on the land or returned after
livestock farming, the field may be used three
ture and meadow if desired. The system may
by cutting out either the second or the sixth year,
omitting the fifth and sixth years, as indicated below.

The two following rotations are suggested as
bating the corn borer:

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Corn (for silage)
Sixth year —Wheat (with sweet clover)

First year
Second year —
Third year —
Fourth year
Fifth year
Sixth year

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Soybeans
Third year —Corn
Fourth year —Wheat (with legume)
Fifth year —Legume

irst year —Corn
econd year —Cowpeas or soybeans
hird year —Wheat (with clover)
ourth year —Clover
ifth year —Wheat (with clover)

last rotation mentioned above allows legumes to be grown four times. may be grown on a sixth field, rotating over all the fields if moved every ars.

Four-Year Rotations

ear —Corn
year —Wheat or oats (with clover)
year —Clover
year —Wheat (with clover)

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

ear —Corn
year —Cowpeas or soybeans
year —Wheat (with clover)
year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

alfa may be grown on a fifth field for four or eight years, which is to be ed with one of the four; or the alfalfa may be moved every five years. us rotated over all five fields every twenty-five years.

Three-Year Rotations

ear —Corn
year —Oats or wheat (with clover)
year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

allowing the clover, in the last rotation mentioned, to grow in the spring reparing the land for corn, we have provided a system in which legumes every acre every year. This is likewise true of the following suggested ear system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

ho in this two-year rotation either oats or wheat is suggested, as a matter by dividing the land devoted to small grain, both of these crops can be imultaneously, thus providing a three-crop system in a two-year cycle. should be understood that in all of the above suggested cropping systems be desirable in some cases to substitute barley or rye for the wheat or oats. ome cases, it may become desirable to divide the acreage of small grain and the same year more than one kind. In all of these proposed rotations d *clover* is used in a general sense to designate either red clover, alsike r sweet clover, or it may include alfalfa used as a biennial. The mixing lfa with clover seed for a legume crop is a recommendable practice. The sweet clover, especially as a green manure for building up depleted soils, as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to Those Occurring in Ogle County)

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Two Farming Systems Provided

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system. Certain modifications have been introduced in recent years.

Definite Crop Rotations Followed

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated (aP = acid phosphate, bP = bonemeal, rP = rock phosphate, sP = slag phosphate)
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
Le = Legume used as green manure
Cv = Cover crop
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed
| = Heavy vertical rule, indicating the beginning of complete treatment
|| = Double vertical rule, indicating a radical change in the cropping system.

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

THE MT. MORRIS FIELD

A University soil experiment field located in Ogle county has been in operation for the past sixteen years. This field is situated near the center of the county at the edge of the town of Mt. Morris. The soil type as shown on the county map is Brown Silt Loam but, as explained in the description of the Brown Silt Loam, this type as mapped in Ogle county embraces several variations. A detailed examination of the soil of the Mt. Morris field discloses five distinguishable types which, on a large-scale map, can be indicated. Such a map is pre-

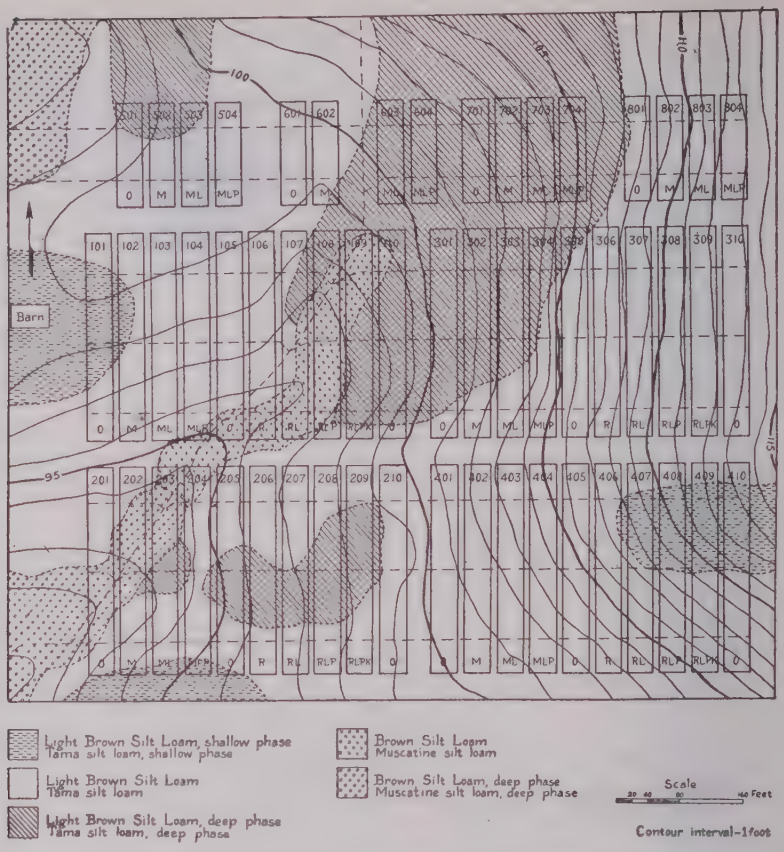


FIG. 2.—DIAGRAM OF THE MT. MORRIS SOIL EXPERIMENT FIELD

This diagram shows the arrangement of plots, the soil treatments applied, the location of the different soil types, and by means of contour lines, the natural drainage.

sented in the accompanying diagram (Fig. 2). The names of these types and their distribution over the field are shown in the diagram. There are also charted the arrangement of plots with their respective soil treatments, and the topography of the land as represented by contour lines. As these lines indicate, the land is somewhat rolling and there is a tendency to wash in some places. The field has been tiled and the drainage is good excepting on some of the lower spots.

The field, which includes 20 acres, is laid out in two general systems of plots which have been designated as the major and the minor systems. Each system embraces four series of plots as described below.

The Major Series—100, 200, 300, 400

The four series of plots constituting the major system, are each made up of 10 fifth-acre plots under the different soil treatments indicated in the accompanying tables and diagram. A rotation system of wheat, corn, oats, and clover was practiced. The crops were managed practically as described for the general plan on page 46 until 1921, when it was planned to remove all clover as hay,

and to discontinue the return of oat straw. In 1922 the return of the wheat straw was also discontinued as well as the application of limestone. In 1923 the phosphate applications were evened up on all phosphate plots to a total amount of 4 tons an acre and no more will be applied for an indefinite period.

Since the Mt. Morris field is located in Ogle county, a complete record of the yields of all crops grown is included in this report. The results for the major series are given in detail in Table 7 and these results are summarized in Table 8 to show the average annual yields per acre for the different kinds of crops, including the years since complete soil treatment on the respective plots has been in effect.

In looking over these results, one may observe first the beneficial effect of farm manure. The annual crop increases due to the use of manure alone amount to over 14 bushels an acre for corn, nearly 9 bushels of oats, almost 5 bushels of wheat, and about ½ ton of clover. Organic manure furnished by "residues" has likewise proved beneficial to all crops, but not in the same degree as stable manure.

Limestone in addition to organic manures has been used with good effect, the improvement being especially marked in the residues system.

Rock phosphate has produced no significant effect applied with manure and limestone. In the corresponding residues system the increases in yield obtained from rock phosphate are somewhat larger, but they have not been sufficient to cover the cost of the phosphate applied.

Potassium, in the combination used in these experiments, has produced no results of significance.

FIG. 3.—CORN ON THE MT. MORRIS FIELD

The two pictures represent the extremes in corn production according to soil treatment. Where the untreated land has produced as a fourteen-year average 44.6 bushels an acre, the land under the residues, limestone, phosphate, potash treatment has yielded 67.2 bushels. The most profitable treatment on this field, however, has been that of residues and limestone, which has produced 62.2 bushels an acre.

TABLE 7.—MT. MORRIS FIELD: SERIES 100, 200, 300, 400
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1910 Barley[1]	1911 Corn[2]	1912 Oats[2]	1913 Clover[5]	1914 Wheat[6]	1915 Corn	1916 Oats	1917 Clover	1918 Wheat	1919 Corn	1920 Oats	1921 Clover	1922 Wheat	1923 Corn	1924 Oats	1925 Clover	1926 Wheat
101	0.....	44.6	53.8	49.1	(3.17)	40.5	17.9	67.0	(1.23)	16.6	47.1	57.2	(1.53)	28.5	38.4	66.9	(1.73)	29.2
102	M.....	42.9	54.1	50.0	(3.70)	42.8	36.7	71.6	(1.72)	22.5	58.8	85.2	(1.91)	34.8	61.8	81.7	(2.13)	33.2
103	ML.....	30.2	46.7	27.0	(2.37)	36.2	41.0	63.0	(2.41)	25.6	61.7	85.0	(1.89)	42.3	77.1	90.9	(2.26)	42.7
104	MLrP....	26.4	46.5	40.3	(2.18)	36.8	39.5	63.8	(2.52)	28.4	60.4	88.4	(1.90)	41.7	69.3	92.8	(2.15)	39.8
105	0.....	27.3	51.5	43.1	(2.59)	37.3	16.0	59.5	.50	20.0	47.6	67.0	(2.00)	36.3	37.6	67.7	(1.99)	29.1
106	R.....	23.1	52.1	39.4	.58	38.4	20.9	60.0	1.10	20.9	61.2	66.6	(2.11)	34.9	46.8	70.0	(.74)	31.2
107	RL.....	32.8	53.5	41.9	1.00	42.8	35.2	61.9	1.33	24.0	64.9	93.8	(2.45)	39.3	64.1	67.5	(.82)	38.4
108	RLrP....	30.7	57.9	47.5	.83	43.4	38.0	54.7	1.17	25.8	81.0	93.4	(2.17)	40.7	66.1	72.3	(.82)	42.0
109	RLrPK...	34.7	52.9	48.4	.92	47.4	40.5	62.8	.83	26.6	68.1	77.0	(2.20)	41.5	75.9	73.0	(.86)	45.6
110	0.....	30.7	55.7	41.6	(3.66)	44.6	19.7	30.3	(1.25)	12.6	35.5	68.3	(1.45)	31.8	43.3	66.6	(2.13)	25.4
		Soy-beans[1]	Wheat[3]	Corn[4]	Oats	Clover	Wheat	Corn	Oats	Soy-beans	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats	Clover
201	0.....	17.8	20.8	48.6	52.8	(1.85)	31.7	29.5	76.2	(1.76)	27.5	36.1	35.5	(2.12)	8.5	31.4	55.2	(.50)
202	M.....	15.8	16.2	56.8	63.0	(2.74)	35.9	43.8	85.2	(1.89)	24.2	42.2	43.9	(3.28)	24.8	46.6	72.0	(1.63)
203	ML.....	15.2	15.4	57.4	50.3	(3.44)	40.1	50.7	97.3	(1.71)	29.2	54.9	48.3	(3.30)	36.6	50.2	88.8	(2.75)
204	MLrP....	12.3	16.5	58.7	61.7	(3.52)	44.0	51.0	95.5	(2.20)	30.5	51.6	48.3	(3.08)	38.3	55.4	84.2	(2.89)
205	0.....	16.1	17.0	49.6	48.8	(1.74)	30.8	33.3	78.4	14.0	20.0	34.6	30.3	(1.93)	16.8	32.2	53.3	(.38)
206	R.....	16.1	16.3	45.8	62.5	1.00	37.7	42.9	81.1	16.7	23.3	42.1	31.7	(2.87)	17.9	38.4	69.1	(.51)
207	RL.....	16.3	18.2	48.8	63.3	1.25	42.1	55.5	95.8	17.7	32.5	63.2	48.6	(3.57)	30.0	43.8	94.7	(1.97)
208	RLrP....	14.5	21.3	53.0	69.2	1.00	47.1	57.2	99.4	21.3	33.3	61.9	43.9	(3.83)	35.3	45.0	90.9	(2.38)
209	RLrPK...	11.8	23.5	62.1	63.1	1.67	48.2	56.5	101.4	20.3	31.7	64.6	52.5	(3.99)	38.0	48.0	97.2	(2.68)
210	0.....	12.2	22.0	51.1	48.0	1.50	42.9	42.4	74.5	(1.91)	29.2	42.3	28.9	(2.47)	15.7	37.2	51.1	(.29)

[1]No treatment. [2]Residues only. [3]No manure or lime. [4]No lime. [5]Residues and lime only. [6]No manure.

TABLE 7.—MT. MORRIS FIELD: Series 100, 200, 300, 400—*Concluded*

Plot No.	Soil treatment applied	1910 Oats[1]	1911 Soy-beans[2]	1912 Barley[3]	1913 Corn	1914 Oats	1915 Clover	1916 Wheat	1917 Corn	1918 Oats	1919 Soy-beans	1920 Wheat	1921 Corn	1922 Oats	1923 Clover	1924 Wheat	1925 Corn	1926 Oats
301	0.....	54.2	13.7	32.2	57.5	57.3	(4.35)	13.3	28.9	77.8	(1.36)	34.4	57.6	68.4	(1.31)	33.9	65.9	50.6
302	M.....	53.1	18.3	31.3	72.9	56.4	(4.24)	17.6	48.2	76.9	(1.51)	42.5	69.9	72.0	(1.58)	34.9	74.6	61.9
303	ML.....	50.8	16.0	35.8	70.7	55.5	(4.18)	19.8	56.2	74.4	(1.88)	46.2	70.2	82.2	(2.08)	43.7	79.9	74.8
304	MLrP....	51.6	17.4	33.3	67.1	51.7	(4.24)	24.8	57.4	82.8	(1.64)	46.1	74.0	80.5	(1.76)	44.7	85.9	72.7
305	0.....	70.9	15.3	31.5	58.4	43.8	.42	17.0	31.0	82.2	12.9	26.2	50.7	44.8	(.90)	29.6	58.8	33.6
306	R.....	68.7	18.5	30.2	66.1	50.0	.50	19.7	38.0	78.4	15.2	31.8	46.6	56.6	(1.36)	34.0	63.8	39.8
307	RL.....	75.8	15.9	31.9	69.2	47.0	.42	22.3	48.7	75.0	20.0	42.0	63.3	77.0	(2.19)	43.3	85.4	62.5
308	RLrP....	62.5	19.6	33.4	76.8	56.2	.17	26.8	51.7	76.9	20.0	48.3	64.7	76.1	(2.50)	45.2	87.0	70.0
309	RLrPK...	78.1	16.9	39.3	68.9	54.2	.08	28.7	56.4	70.3	19.7	48.5	69.1	83.3	(2.45)	38.0	91.0	69.7
310	0.....	62.5	18.2	29.8	51.5	53.1	(3.37)	21.2	30.0	75.2	(1.45)	32.8	43.7	45.0	(1.01)	32.5	50.1	36.9
		Corn[1]	Oats[2]	Clover[2]	Wheat[4]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn
401	0.....	34.3	60.2	(2.10)	25.2	58.2	70.0	(2.16)	7.1	55.2	51.6	(1.61)	29.4	63.7	32.3	(3.15)	19.4	46.9
402	M.....	35.1	63.6	(2.67)	26.2	71.3	67.0	(2.74)	7.8	70.4	60.2	(2.14)	31.4	76.5	46.9	(3.70)	28.0	59.6
403	ML.....	36.9	60.3	(2.87)	29.5	73.6	67.0	(3.09)	11.5	74.1	52.3	(2.91)	33.3	74.8	57.7	(4.39)	42.2	66.2
404	MLrP....	35.8	70.3	(2.75)	33.3	68.8	69.4	(3.01)	11.8	75.1	50.0	(2.83)	35.8	82.8	59.4	(4.19)	44.5	61.8
405	0.....	37.1	65.3	(2.73)	27.8	58.4	66.4	.58	7.8	57.0	55.9	(1.01) 3.96	27.4	67.7	36.7	(2.59)	20.9	41.1
406	R.....	42.0	65.0	1.42	33.5	59.5	64.7	.50	8.1	68.1	60.9	(1.27) 4.36	26.3	73.0	39.7	(3.16)	23.3	49.7
407	RL.....	41.2	71.1	1.42	32.0	64.5	57.7	.67	11.5	74.1	64.4	(1.59) 4.36	29.7	80.5	54.4	(4.04)	36.8	58.1
408	RLrP....	40.3	68.3	1.25	33.3	66.4	57.2	.50	13.6	78.3	65.9	(1.60) 3.72	33.8	79.6	56.6	(4.69)	42.5	65.2
409	RLrPK...	40.9	68.3	1.17	36.8	67.5	57.3	.42	13.1	79.1	68.0	(1.77) 3.65	33.8	90.0	55.8	(4.03)	42.5	65.7
410	0.....	36.2	63.0	(2.18)	30.3	57.5	71.6	(2.23)	5.9	55.6	52.3	(1.40)	24.8	63.0	32.5	(2.40)	21.8	38.2

[1]No treatment. [2]Residues only. [3]No manure or lime. Wheat winterkilled; barley grown as a substitute crop. [4]No manure.

TABLE 8.—MT. MORRIS FIELD: SERIES 100, 200, 300, 400, SUMMARY OF CROP YIELDS
Average Annual Yields, 1913-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *14 crops*	Oats *14 crops*	Wheat *12 crops*	Clover[1] *10 crops*	Soybeans *2 crops*
1	0	45.3	58.5	23.3	(1.96)	(1.56)
2	M	59.5	67.4	28.1	(2.53)	(1.70)
3	ML	64.4	70.5	34.4	(2.97)	(1.80)
4	MLP	64.3	71.5	35.9	(2.92)	(1.92)
5	0	44.6	54.9	23.5	(1.61)	13.5
6	R	51.2	59.4	25.8	(1.77)	16.0
7	RL	62.2	68.8	32.7	(2.24)	18.9
8	RLP	65.6	70.2	36.2	(2.23)	20.7
9	RLPK	67.2	70.4	36.3	(2.24)	20.0
10	0	43.6	52.4	24.6	(1.79)	(1.68)
	Crop Increases					
	M over 0	14.2	8.9	4.8	(.57)	(.14)
	R over 0	6.6	4.5	2.3	(.16)	2.5
	ML over M	4.9	3.1	6.3	(.44)	(.10)
	RL over R	11.0	9.4	6.9	(.47)	2.9
	MLP over ML	− .1	1.0	1.5	−(.05)	(.12)
	RLP over RL	3.4	1.4	3.5	−(.01)	1.8
	RLPK over RLP	1.6	.2	.1	(.01)	− .7

[1]Some clover seed evaluated as hay.

The Minor Series—500, 600, 700, 800

The plots of the minor series were not laid out until 1912. At this time a rotation of potatoes two years, and alfalfa six years, was started. Manure was applied at the rate of 15 tons an acre for each potato crop. In the beginning 4 tons of limestone an acre was applied, and thereafter the applications were continued at the rate of ½ ton a year, all applied in preparation for the alfalfa. Rock phosphate was applied at the annual acre rate of 500 pounds before the first potato crop. In 1921 the rotation was changed to corn, barley, sweet clover, and alfalfa. The manure was evened up to a total of 30 tons an acre, the limestone to 9 tons, and the rock phosphate to 3½ tons, no more of these materials to be applied for an indefinite period.

Table 9 presents an outline of the cropping history of these series, while Table 10 summarizes the work in terms of average annual acre-yields for those years since the plots have been under their full treatments.

The general beneficial effect of farm manure is again demonstrated. The use of limestone has also given profitable returns, particularly in the alfalfa hay. The negative result with sweet clover seed is probably due to the fact that the ranker vegetative growth observed on the lime plots was detrimental to seed production.

Here, as on the major system of plots, with a different crop rotation, rock phosphate has produced no significant effect.

TABLE 9.—MT. MORRIS FIELD: SERIES 500, 600, 700, 800
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1913 Potatoes	1914 Potatoes	1915 Barley hay	1916 Alfalfa	1917 Alfalfa[3]	1918 Alfalfa	1919 Alfalfa	1920 Alfalfa	1921 Barley	1922 Sweet clover seed	1923 Corn	1924 Barley	1925 Alfalfa	1926 Alfalfa
501	0	112.5	78.3	(.52)	(1.16)	....	(1.47)	(3.18)	(2.66)	22.1	2.92	61.2	29.4	(0.00)	(1.93)
502	M	163.2	158.0	(2.33)	(3.88)	....	(2.57)	(4.98)	(3.21)	36.9	2.92	66.4	34.4	(0.00)	(2.21)
503	ML	184.3	173.8	(1.96)	(5.33)	....	(4.46)	(6.10)	(4.22)	44.4	3.05	70.6	40.4	(1.38)	(3.90)
504	MLP	207.7	175.0	(1.79)	(5.10)	....	(4.39)	(6.26)	(3.93)	40.0	2.83	77.2	41.0	(1.24)	(3.94)
		Alfalfa[1,2]	Alfalfa[1]	Potatoes	Potatoes	Alfalfa[3]	Alfalfa	Alfalfa	Alfalfa	Corn	Barley	Sweet clover seed	Corn	Barley	Timothy-alsike
601	0	....	(5.32)	197.8	71.7	....	(4.00)	(5.31)	(2.27)	67.8	52.1	6.96	59.4	33.8	(1.46)
602	M	....	(5.47)	266.7	137.0	....	(5.04)	(6.03)	(3.16)	57.8	57.9	8.08	61.0	43.9	(2.01)
603	ML	....	(6.32)	252.5	145.0	....	(5.37)	(5.08)	(3.68)	74.0	60.0	6.28	66.4	71.9	(2.45)
604	MLP	....	(6.70)	265.8	144.7	....	(5.19)	(5.52)	(4.08)	77.6	57.5	5.96	53.0	71.5	(2.54)
		Alfalfa[1,2]	Alfalfa[1]	Alfalfa[1]	Alfalfa[1]	Potatoes	Potatoes	Alfalfa	Alfalfa	Alfalfa	Corn	Barley	Sweet clover seed	Corn	Barley
701	0	....	(5.78)	(5.01)	(4.98)	94.8	101.0	(3.03)	(2.48)	(3.61)	86.0	37.5	1.67	76.6	51.4
702	M	....	(5.95)	(5.16)	(5.77)	130.3	154.2	(3.74)	(3.79)	(3.78)	88.8	52.3	1.83	84.8	60.4
703	ML	....	(6.68)	(5.57)	(5.66)	126.5	158.7	(3.91)	(4.94)	(4.62)	87.8	58.3	.50	83.4	58.5
704	MLP	....	(6.67)	(5.61)	(5.57)	119.8	150.2	(4.06)	(4.93)	(4.54)	88.2	59.2	.50	86.6	62.5
		Alfalfa[1,2]	Alfalfa[1]	Alfalfa[1]	Alfalfa[1]	Alfalfa[1,3]	Alfalfa[1]	Potatoes	Potatoes	Alfalfa seeding	Alfalfa	Alfalfa	Alfalfa	Alfalfa	Corn
801	0	....	(5.56)	(4.98)	(5.27)	....	(3.50)	46.7	15.7	....	(4.26)	(3.50)	(3.09)	(2.62)	57.8
802	M	....	(5.51)	(4.80)	(5.34)	....	(3.73)	61.7	31.3	....	(4.90)	(4.40)	(3.33)	(3.13)	64.6
803	ML	....	(5.42)	(4.55)	(5.40)	....	(3.09)	71.7	35.5	....	(5.39)	(5.05)	(4.19)	(4.03)	62.0
804	MLP	....	(5.77)	(4.90)	(5.17)	....	(3.26)	62.7	33.3	....	(5.58)	(5.59)	(4.44)	(4.14)	65.0

[1]No manure. [2]Series 600, 700, 800 harvested as a unit. [3]Alfalfa winterkilled in 1917.

TABLE 10.—MT. MORRIS FIELD: SERIES 500, 600, 700, 800, SUMMARY OF CROP YIELDS
Average Annual Yields, 1913-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Potatoes *8 crops*	Alfalfa *19 crops*	Corn *6 crops*	Barley *6 crops*	Sweet clover seed *3 crops*	Timothy-alsike *1 crop*
1	0	89.8	(2.35)	68.0	37.8	3.83	(1.46)
2	M	137.8	(3.03)	70.6	49.3	4.28	(2.01)
3	ML	143.5	(3.77)	74.0	55.4	3.24	(2.45)
4	MLP	141.1	(3.89)	74.7	55.3	3.10	(2.54)
	Crop Increases						
	M over 0	48.0	(.71)	2.6	11.5	.45	(.55)
	ML over M	5.7	(.71)	3.4	6.1	−1.04	(.44)
	MLP over ML	− 2.4	(.12)	.7	− .1	− .14	(.09)

THE DIXON FIELD

A summary of the results of the Dixon experiment field are presented here, inasmuch as the soil of this field is similar to some of that found in Ogle county.

This field, which includes about 21 acres, is laid out into two general systems of plots, a major and a minor system. The results from the major system will be considered here.

The rotation practiced has been wheat, corn, oats, and clover. The treatment of the plots and management of the crops have been, for the most part, according to the general plan described above on page 46. The more important modification of this plan has been the discontinuance within the last few years of the applications of limestone, phosphate, and straw residues.

TABLE 11.—DIXON FIELD: SERIES 100, 200, 300, 400, SUMMARY OF CROP YIELDS
Average Annual Yields, 1912-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *15 crops*	Oats *14 crops*	Wheat *11 crops*	Barley *1 crop*	Clover[1] *9 crops*	Soybeans *4 crops*
1	0	36.3	49.0	20.3	43.3	(1.73)	(1.46)
2	M	55.6	61.7	26.9	46.4	(2.44)	(1.78)
3	ML	59.7	65.5	31.0	55.2	(2.70)	(1.92)
4	MLP	62.3	67.3	34.2	58.3	(2.82)	(1.97)
5	0	42.6	54.4	21.7	49.5	(1.35)	11.8
6	R	50.5	58.7	24.8	53.8	(1.47)	13.5
7	RL	56.4	62.6	28.0	54.5	(1.77)	13.3
8	RLP	57.7	65.1	32.9	59.0	(2.04)	13.3
9	RLPK	61.1	64.6	33.7	56.9	(2.18)	14.0
10	0	41.3	52.0	20.0	45.4	(1.89)	(1.45)
	Crop Increases						
	M over 0	19.3	12.7	6.6	3.1	(.71)	(.32)
	R over 0	7.9	4.3	3.1	4.3	(.12)	1.7
	ML over M	4.1	3.8	4.1	8.8	(.26)	(.14)
	RL over R	5.9	3.9	3.2	.7	(.30)	− .2
	MLP over ML	2.6	1.8	3.2	3.1	(.12)	(.05)
	RLP over RL	1.3	2.5	4.9	4.5	(.27)	0.0
	RLPK over RLP	3.4	− .5	.8	− 2.1	(.14)	.7

[1]Including some seed crops evaluated in this summary as hay.

Table 11 gives a summary of the results in terms of the average annual crop yields obtained since the plots have been under complete treatment.

In considering these results, the most striking feature to be observed is the outstanding effect of farm manure. The average annual increase per acre in crop yields due to the use of manure alone amounts to nearly 20 bushels of corn, more than 12 bushels of oats, nearly 7 bushels of wheat, ⅔ of a ton of clover, and ⅓ of a ton of soybean hay.

Organic manure in the form of crop residues has also produced increases in yields altho not to the extent of those produced by animal manure.

Limestone in addition to organic manures has, with a single exception, effected more or less improvement, probably sufficient to cover the expense of application.

Rock phosphate, as usual, shows up to best advantage used with residues on the wheat crop. The effect on other crops, however, has been such that the increases in yield are not sufficient to cover the cost of the application under existing market conditions.

Altho potassium has produced an average increase of 3.5 bushels an acre in corn, the effects on other crops are such as to render its use unprofitable in growing these common field crops.

THE VIENNA FIELD

Inasmuch as Ogle county embraces in its Yellow Silt Loam and certain other soil types considerable land that is subject to destruction thru erosion or washing, an account of the experiments on the Vienna field should be of interest in this report.

The Vienna field, located in Johnson county, is representative of the sloping erodible land so prevalent in that section of the state. Experiments were conducted nine years with the purpose of testing different methods of reclaiming this badly gullied land and preventing further erosion. The whole field with the exception of about three acres had been abandoned because so much of the surface soil had washed away and there were so many gullies as to render further cultivation of this land unprofitable. Experiments were started at once to reclaim this land, the different methods described below being used for this purpose.

The field was divided into five sections. The sections designated as A, B, and C were divided into four plots each, and D into three plots. On section A, which included the steepest part of the area and contained many gullies, the land was built up into terraces at vertical intervals of five feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

On section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges sufficiently high so that on the occasion of a heavy rainfall, if the water breaks over, it will run over in a broad sheet rather than in narrow channels. At the steepest part of the slope hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the

FIG. 4.—VIEW OF AN UNIMPROVED HILLSIDE JUST OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 5

soil and practicing deep contour plowing and contour planting. With two exceptions, about 8 loads of manure per acre were turned under each year for the corn crop.

The land on section D was washed to about the same extent as that of section C. As a check on the different methods of reducing erosion, the land on section D was farmed in the most convenient way, without any special effort being made to prevent washing.

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

Sections A, B, C, and D were not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil

FIG. 5.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD. THIS LAND FORMERLY HAD BEEN BADLY ERRODED. COMPARE WITH FIG. 4

TABLE 12.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields, 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons per acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except D which had but three plots.

Table 12 contains a summarized statement of the results obtained.

These results indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels per acre, as against 14.1 bushels for series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 4 and 5 will serve to indicate the possibility of improving this type of soil.

THE OQUAWKA FIELD

In 1913 the University established an experiment field on Dune Sand, Terrace, in Henderson county, near the Mississippi river. This field is divided into six series of plots. Corn, soybean, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

Table 13 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 47.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been practically doubled. The limestone has also produced good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite indifferent to treatment with rock phosphate. The analyses show, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

Altho the results show an increase of about 2 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment.

TABLE 13.—OQUAWKA FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields, 1915-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *12 crops*	Soybeans[1] *12 crops*	Wheat *12 crops*	Sweet clover[2] *8 crops*	Rye *10 crops*	Alfalfa *9 crops*
1	0	20.2	(.99)	8.7	0.0	12.1	(.42)
2	M	25.3	(1.19)	12.0	0.0	13.7	(.92)
3	ML	33.4	(1.61)	16.1	1.03	24.7	(2.37)
4	MLP	33.9	(1.56)	16.4	1.05	23.4	(2.45)
5	0	19.7	(.77)	10.7	0.0	12.7	(.40)
6	R	21.2	(.82)	12.2	0.0	12.9	(.45)
7	RL	37.2	(1.17)	15.1	1.41	24.0	(2.11)
8	RLP	37.0	(1.25)	15.6	1.28	24.1	(2.10)
9	RLPK	39.2	(1.20)	14.9	1.49	26.0	(2.17)
10	0	18.6	(.71)	9.6	0.0	10.3	(.29)
	CROP INCREASES						
	M over 0	5.1	(.20)	3.3	0.0	1.6	(.50)
	R over 0	1.5	(.05)	1.5	0.0	.2	(.05)
	ML over M	8.1	(.42)	4.1	1.03	11.0	(1.45)
	RL over R	16.0	(.35)	2.9	1.41	11.1	(1.66)
	MLP over ML	.5	(−.05)	.3	.02	− 1.3	(.08)
	RLP over RL	− .2	(.08)	.5	− .13	.1	(−.01)
	RLPK over RLP	2.2	(−.05)	− .07	.21	1.9	(.07)

[1]Eleven regular crops, together with the extra crop described in the following footnote, averaged as 11 crops. Several crops which were harvested as seed are evaluated in this summary as hay.

[2]Some hay evaluated as seed. In 1918 the sweet clover was killed by early cutting for a hay crop. Soybeans were seeded in July and the ensuing crop is included in the soybean average.

The slight increases from the use of potassium appearing in the other crops are scarcely significant.

A significant fact which the above summary does not bring out is that improvement under favorable treatment has been progressive as evidenced by a very marked upward trend in production after the first few years. For example, it may be noted that the yield of corn under the limestone-residues treatment has been 37.2 bushels an acre as an average for the 12 crops since full treatment started, but if we take an average of the last five crops, the yield rises to 42.9 bushels. Likewise the wheat yield under this same treatment for the 11-year average is 15.1 bushels, but the average for the last five years is 22.3 bushels.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

THE MANITO FIELD

The results secured on the Manito experiment field which was located on Deep Peat and which was in operation during the years 1902 to 1905, inclusive, are presented in Table 14.

There were ten plots receiving the treatments indicated in the table. Where potassium was applied, the yield was three to four times as large as where

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 6.—ALFALFA ON THE OQUAWKA FIELD

These pictures show the possibility of improving this unproductive sandy land of the Oquawka field. Both plots were seeded alike to alfalfa. Where manure alone was applied, the crop was a total failure, but where limestone in addition to manure was applied, nearly 4½ tons of alfalfa hay was obtained as the season's yield.

nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than

TABLE 14.—MANITO FIELD: DEEP PEAT
Annual Crop Yields—Bushels per Acre

Plot No.	Soil treatment 1902	Corn 1902	Corn 1903	Soil treatment 1904	Corn 1904	Corn 1905
1	None	10.9	8.1	None	17.0	12.0
2	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1
3	Kainit, 600 lbs.	30.4	32.4	Limestone, 4000 lbs., Kainit, 1200 lbs	49.6	47.3
4	Kainit, 600 lbs., Acidulated bone, 350 lbs.	30.3	33.3	Kainit, 1200 lbs., Steamed bone, 395 lbs.	53.5	47.6
5	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs.	44.5	47.3
8	Kainit, 600 lbs.	36.8	37.7	Kainit, 600 lbs.	44.0	46.0
9	Kainit, 300 lbs.	26.4	25.1	Kainit, 300 lbs.	41.5	32.9
10	None	[1]	14.9	None	26.0	13.6

[1]Yield not recorded for 1902.

the kainit. However, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the total yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) appear to be insufficient.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1925
33 Saline, 1926
34 Marion, 1926
35 Will, 1926
36 Woodford, 1927
37 Lee, 1927
38 Ogle, 1927

NOV 10

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT NO. 39

LOGAN COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, and L. H. SMITH

URBANA, ILLINOIS, OCTOBER, 1927

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Logan county was conducted, and to Mr. F. A. Fisher and Mr. O. I. Ellis who, as leaders of the field parties, were in direct charge of the mapping.

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LOGAN COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

LOCATION AND CLIMATE OF LOGAN COUNTY

Logan county is in almost the exact center of the state of Illinois. It has a total area of 616.43 square miles, three-quarters of which is upland.

The climate of Logan county is typical of central Illinois. It is characterized by a wide range between the extremes of winter and summer and has an abundant, usually well-distributed rainfall. The great range in temperature for any one year for the sixteen-year period from 1910 to 1925, as recorded at the Lincoln Weather Bureau Station, was 130 degrees, in 1914. The highest temperature recorded was 105°, in 1918; the lowest, 29° below zero, in 1914. The average date of the last killing frost in spring is May 4; the earliest in the fall, October 13. The average length of the growing season is 162 days.

The average annual rainfall, as recorded for this sixteen-year period at Lincoln, was 35.54 inches. The average rainfall by months for this period was as follows: January, 1.91 inches; February, 1.48; March, 3.12; April, 3.45; May, 4.30; June, 3.47; July, 2.95; August, 3.40; September, 3.82; October, 2.90; November, 2.07; December, 1.99.

AGRICULTURAL PRODUCTION

Logan county is agricultural in its interests, over 90 percent of the land being suitable for farming. According to the Fourteenth Census of the United States there were 2,234 farms in the county in 1920, a decrease of 86 since 1910 and 171 since 1900. About 65 percent were operated by tenants, an increase of about 6 percent in twenty years.

The principal crops are those common to the corn belt, as shown by the following figures for the year 1919.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	126,220	5,191,270 bu.	41.1 bu.
Oats	56,193	1,692,878 bu.	30.1 bu.
Wheat	89,448	1,852,127 bu.	20.7 bu.
Timothy	4,820	6,179 tons	1.28 tons
Timothy and clover mixed	2,957	3,857 tons	1.30 tons
Clover	13,232	14,494 tons	1.09 tons
Alfalfa	783	2,029 tons	2.59 tons
Silage crops	659	6,002 tons	9.10 tons
Corn for forage	869	2,393 tons	2.75 tons

These figures are for but a single year. For the ten-year period 1916 to 1925 the U. S. Department of Agriculture gives the average yield of corn as 40.5 bushels; oats, 35.0 bushels; winter wheat, 21.4 bushels; tame hay, 1.29 tons.

The total value of all livestock and livestock products produced in 1919 was $5,858,500, or a little over one-third the value of crops produced that year. The

[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

following figures, taken from the 1920 Census, show the character of the live-stock interests in the county.

Animals and Animal Products	*Number*	*Value*
Horses	17,999	$1,781,591
Mules	2,342	323,669
Beef cattle	8,778	548,118
Dairy cattle	13,287	894,089
Sheep	4,760	55,518
Swine	47,721	896,473
Chickens and other poultry	280,562	272,718
Chickens and eggs produced	.....	679,102
Dairy products produced	.....	373,954

SOIL FORMATION

GLACIATION

One of the most important periods in the geological history of the county, from the standpoint of soil formation, was the Glacial period. During and immediately following this remote period, the material that later formed the mineral portion of the soils was being deposited. At that time snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an amount that the mass pushed outward from these centers, chiefly southward, until a region was reached where the ice melted as rapidly as it advanced. In moving across the country from the far north, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even immense masses of rock. Some of these materials were carried for hundreds of miles and rubbed against surface rocks and against each other until largely ground into powder. When the ice sheet, or glacier, reached the limit of its advance, the rock material carried by it accumulated along the front edge in a broad, undulating ridge or moraine. With rapid melting, the terminus of the glacier receded, and the material was deposited somewhat irregularly over the area previously covered. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift. The average depth of this deposit over the state of Illinois is estimated at 115 feet.

Previous to the ice invasion this region generally was not well suited to agriculture because of its rough and hilly character. Logan county was covered by the Illinoisan glaciation and in the northeast corner by the Wisconsin glaciation. The general effect of these glaciers was to change the surface from hilly to gently undulating by rubbing down the hills and filling the valleys. Several moraines were formed in this county.

Altho it did not touch the county, a later ice sheet, known as the Iowan, played an important role in the formation of the soils. During the time when the melting ice front of this Iowan glacier lay to the north of the area now comprizing Logan county, immense volumes of water, heavily laden with fine sediment, flowed from the ice. This water filled the drainage channels and overflowed the adjacent lowlands, forming terraces. Following each flood state, the water would recede and the sediment which had been deposited would be picked up by the wind and redeposited on the upland.

This wind-blown deposit, known as loess, varies from 60 to 75 inches in thickness over much of the county and apparently it is the material from which the upland soils of Logan county are formed.

PHYSIOGRAPHY AND DRAINAGE

The topography of Logan county is favorable to good surface drainage with the exception of a few areas, notably in the vicinity of Elkhart, in the region south of Mt. Pulaski, and between Hartsburg and Emden. Even these relatively flat-lying areas, however, are sufficiently undulating so that drainage may be provided without difficulty. The north corner of the county in the region

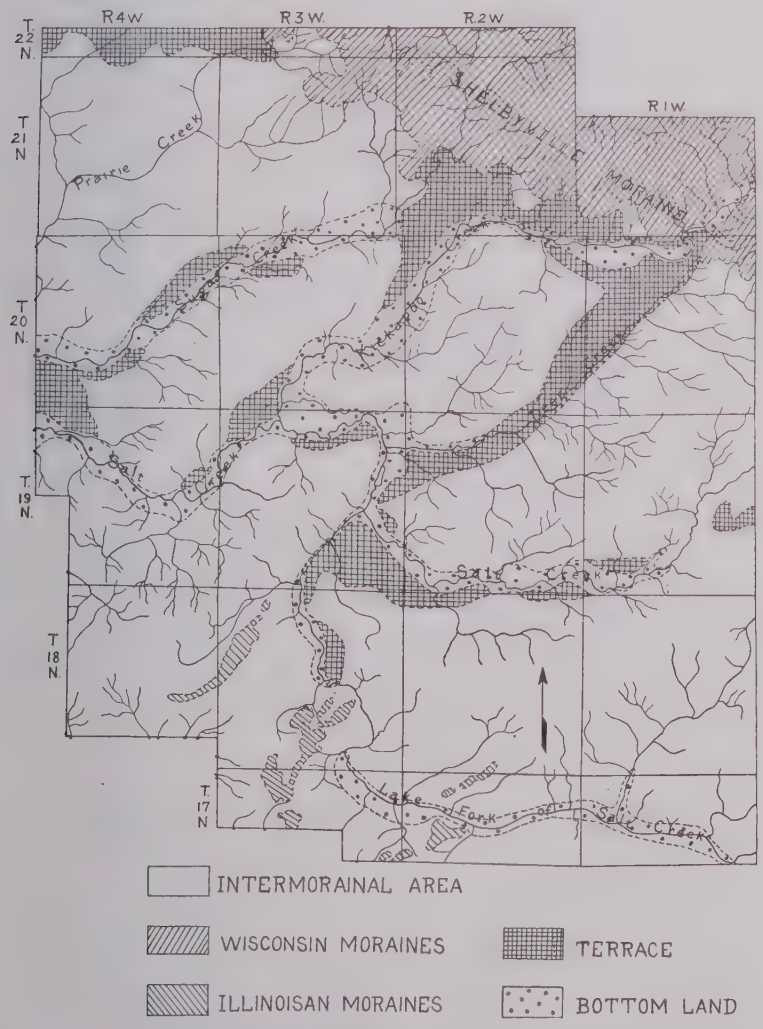


FIG. 1.—DRAINAGE MAP OF LOGAN COUNTY SHOWING STREAM COURSES, GLACIATIONS, AND TERRACE AND BOTTOM-LAND AREAS

of San Jose is rolling and has a dune-like topography. The soil map shows a number of morainal hills south and west of Mt. Pulaski.

The drainage of the county is well taken care of by Salt creek and its tributaries. All the drainage of the county finds its way into Sangamon river thru Salt creek, with the exception of a few square miles in the southwest corner, which drain directly into the Sangamon. The wide bottoms and terraces along Salt creek and its tributaries, Deer creek, Kickapoo creek, and Sugar creek, show that stream action was much more vigorous at one time in the history of this region than it is now.

SOIL DEVELOPMENT

During the time which has elapsed since the last ice invasion, weathering and other processes have been active, resulting in the formation of the soils of the county as we know them today. When first deposited, the general composition of any soil material, particularly loess, is rather uniform. With the passing of time, however, various physical, chemical, and biological agencies of weathering form soil out of the parent material by some or all of the following processes: the leaching of certain elements, the accumulation of others; the chemical reduction of certain compounds, the oxidation of others; the translocation of the finer soil particles, and the arrangement of them into zones or horizons; and the accumulation of organic matter from the growth and decay of vegetable material. One of the very pronounced characteristics observed in most soils is that they are composed of more or less distinct strata, called horizons. As explained somewhat more fully in the Appendix, these horizons are named, from the surface down: A, the layer of extraction; B, the layer of concentration or accumulation; and C, the layer of less-altered material, or the layer in which weathering has had less effect. The development of horizons in a soil is an indication of its age.

SOIL GROUPS

The soils of Logan county have been divided into four groups, as follows:

Upland Prairie Soils, dark colored and usually rich in organic matter, the organic matter having been derived from the decaying roots of the wild prairie grasses which occupied this land for thousands of years.

Upland Timber Soils, including those zones along stream courses over which forests grew for a long period of time. These contain in general less organic matter than the prairie soils.

Terrace Soils, including bench lands and second bottoms formed by deposits from flooded streams overloaded with sediment, perhaps at the time of the melting of the glaciers.

Swamp and Bottom Lands, which include the flood plains along the streams and some poorly drained muck and peat areas. The soil map shows the Swamp and Bottom Lands as divided into two groups, the Old and the Late. This division, as made, was geological, but according to the present-day conception of the matter it has no significance in a soil classification; hence for the purpose of describing the various swamp and bottom-land types, the two groups are combined into one.

LEGEND

200 Illinoisan Moraines
400 Middle Illinoisan Glaciation
900 Early Wisconsin Moraines

UPLAND PRAIRIE SOILS

26 Brown Silt Loam
20 Black Clay Loam
28 Brown-Gray Silt Loam O
60 Brown Sandy Loam

RACE SOILS

n Silt Loam Over Sand Or Gravel
Clay Loam Over Sand Or Gravel
n Sandy Loam Over Sand Or Gravel
w-Gray Silt Loam Over Sand Or Gravel
n-Gray Silt Loam On Tight Clay

RESIDUAL SOILS

× Rock Outcrop

CONVENTIONAL SIGNS

Railroads
Electric Roads
Public Roads
Private Roads
Morainal Boundaries

Scale
0 ¼ ½ 1 2 Miles

TABLE 1.—SOIL TYPES OF LOGAN COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils (200, 400, 900)			
226, 426, 926	Brown Silt Loam	369.66	236 582	59.97
420, 920	Black Clay Loam	83.66	53 542	13.57
428, 928	Brown-Gray Silt Loam On Tight Clay	.39	250	.06
260, 460	Brown Sandy Loam	1.15	736	.19
		454.86	291 110	73.79
	Upland Timber Soils (200, 400, 900)			
234, 434, 934	Yellow-Gray Silt Loam	35.91	22 982	5.83
235, 435, 935	Yellow Silt Loam	5.98	3 827	.97
464	Yellow-Gray Sandy Loam	.14	90	.02
419	Brown Clay Loam	.39	250	.06
		42.42	27 149	6.88
	Terrace Soils (1500)			
1527	Brown Silt Loam Over Sand or Gravel	38.35	24 544	6.22
1520	Black Clay Loam Over Sand or Gravel	4.16	2 662	.68
1566	Brown Sandy Loam Over Sand or Gravel	.33	211	.05
1536	Yellow-Gray Silt Loam Over Sand or Gravel	3.17	2 029	.50
1528	Brown-Gray Silt Loam On Tight Clay	5.72	3 661	.93
		51.73	33 107	8.38
	Swamp and Bottom-Land Soils (1300, 1400)[1]			
1326, 1426	Deep Brown Silt Loam	39.96	25 574	6.49
1320, 1420	Black Clay Loam	12.00	7 680	1.95
1319, 1419	Brown Clay Loam	8.26	5 286	1.34
1354, 1454	Mixed Loam	7.11	4 550	1.15
		67.33	43 090	10.93
	Miscellaneous			
	Sand or Gravel Pit	.07	45	.01
	Water	.02	13	< .01
		.09	58	.02
	Total	616.43	394 514	100.00

[1]These 1300 and 1400 groups are differentiated on the map but not in the descriptions, as explained on page 4.

Table 1 gives the list of soil types in Logan county, the area of each in square miles and in acres, and also the percentage of the total area. The

accompanying map, shown in 2 sections, gives the location and boundary of each soil type which has been mapped in the county.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN LOGAN COUNTY SOILS

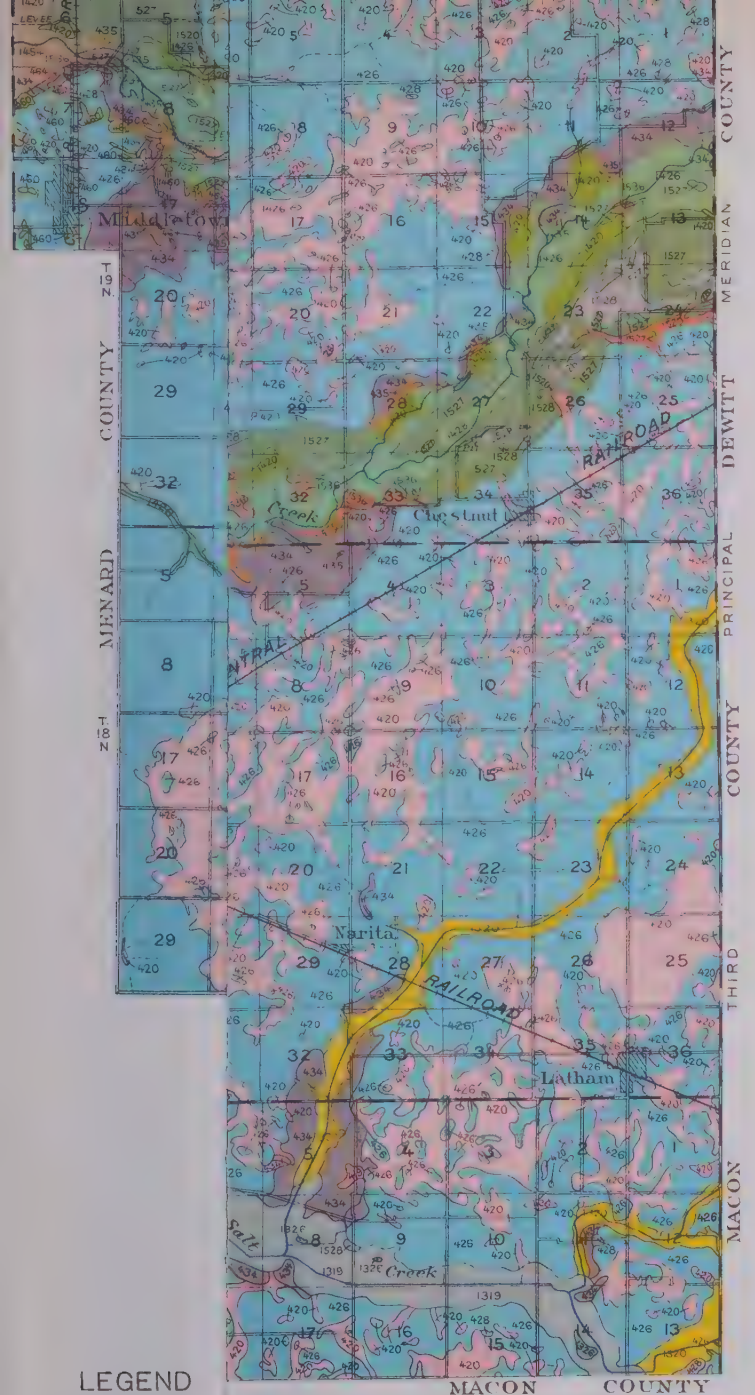
In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches).

These sampling strata correspond approximately in the common kinds of soil to 2 million pounds per acre of dry soil in the upper stratum, and to two times and three times this quantity in the middle and lower strata respectively. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil; but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to in describing the soil types as "horizons A, B, and C." By this system of sampling we have represented separately three zones for plant feeding. The upper, or surface layer, includes at least as much soil as is ordinarily turned with the plow, being the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed. It should be understood, however, that the rate of liberation from their insoluble forms, a matter of at least equal importance, is governed by many factors, and therefore is not necessarily proportional to the total amounts present.

For convenience in making application of the chemical analyses, the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In this the assumption is made that for ordinary types a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2 million pounds. It is understood, of course, that this value is only an approximation, but it is believed that with this understanding it will suffice for the purpose intended. It is a simple matter to convert these figures back to the percentage basis in case one desires to consider the information in that form.

With respect to the presence of limestone and acidity in different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages for the respective types, because of the extreme variations frequently found within a given soil type. In examining each soil type in the field, however, numerous qualitative tests are made which furnish general information



LEGEND

200 Illinoisan Moraines
400 Middle Illinoisan Glacia
900 Early Wisconsin Moraln

UPLAND PRAIRIE SOILS

26 Brown Silt Loam
20 Black Clay Loam
28 Brown-Gray Silt Loam
60 Brown Sandy Loam

E SOILS

t Loam Over Sand Or Gravel
y Loam Over Sand Or Gravel
ndy Loam Over Sand Or Gravel
y Silt Loam Over Sand Or Gravel
y Silt Loam On Tight Clay

RESIDUAL SOILS

× Rock Outcrop

CONVENTIONAL SIGNS

Railroads
Electric Roads
Public Roads
Private Roads
Morainal Boundaries

Scale
0 ¼ ½ 1 2 Miles

regarding the soil reaction, and in the discussion of the individual soil types which follows, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping and soil treatment. It is often desirable, therefore, to determine the lime requirement for a given field, and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (page 29).

THE UPPER SAMPLING STRATUM

In Table 2 are reported the total quantities of organic carbon, nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of surface soil of each type in Logan county.

In connection with this table attention is called to the variation among the soil types with respect to their content of the different plant-food elements. It will be seen from the analyses that variations in the organic-carbon content of the different soils are accompanied by similar variations in the nitrogen content. The organic-carbon content, which serves as a measure of the total organic matter present, averages ten times that of the total nitrogen in the upper sampling stratum. This relationship is explained by the well-established facts that all soil organic matter contains nitrogen, and that most of the soil nitrogen (usually 98 percent or more) is present in a state of organic combination. This close relationship is also maintained in the middle and lower sampling strata, the ratio usually becoming narrower as the depth increases.

The ranges in amount of organic matter and nitrogen are very wide. The upland prairie soils are for the most part relatively high in these constituents, averaging 42,080 pounds of organic carbon in an acre, while the upland timber soils are fairly low, with an average content of 26,090 pounds of this element. Black Clay Loam, Upland, contains the largest amount of organic carbon of any soil in the county. The amount found in this type is 69,970 pounds an acre, with a nitrogen content of 6,220 pounds. The lowest amounts are to be found in the more or less sandy types, such as Brown Sandy Loam and Yellow-Gray Sandy Loam which, because of their loose, open character, permit the rapid oxidation of the organic matter.

Other elements are not so closely associated with each other as are organic matter and nitrogen. However, there is some degree of correlation between sulfur, another element used by growing plants, and organic carbon. This is because a considerable tho varying proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of the organic matter. Most of the Logan county soils are fairly well supplied with sulfur, only the two sandy types above mentioned, and also the two terrace types, Yellow-Gray Silt Loam and Brown Sandy Loam, exhibiting very low values. The range in the surface soil is from a minimum of 340 pounds an acre in Yellow-Gray Sandy Loam to 1,120 pounds in Black Clay Loam, Upland. The sulfur content of the soil is consistently 75 to 80 percent as high as the phosphorus in the upland soils, but only 50 percent as high in the terrace and bottom-land soils. No explanation is

apparent for this variation. The sulfur available to crops is affected not only by the supply in the soil but also by that brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently it is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption, the amount of sulfur thus added to the soil is large. At Urbana during the eight-year period from 1917 to 1924 there was added to the soil by the rainfall, 3.5 pounds of sulfur an acre a month as an average. Similar observations have been made in other localities for shorter periods. At Spring Valley, in Bureau county, the rainfall during six summer months in 1921 brought down 34.5 pounds of sulfur an acre, or an average monthly precipitation of 5.75 pounds. The maximum for a single month was 8.77 pounds, in June. At Toledo, in Cumberland county, from April to November, 1922, the average precipitation was 3 pounds an acre a month. The precipitation at the various points in the state in a single month has varied from a minimum of ¾ of a pound to over 10 pounds an acre. These figures will afford some idea of the amounts of sulfur added by rain and also of the wide variation in these amounts under different conditions.

On the whole, the above facts would indicate that the sulfur added from the atmosphere supplements that contained in the soil, so that there appears to be no need for sulfur fertilizers in Logan county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started at five experimental fields, one of which is in Logan county. These fields are at Raleigh, Toledo, Carthage, Hartsburg, and Dixon. The data from the Hartsburg experiment field are given in the Supplement of this Report, page 50.

With regard to total phosphorus, the two upland sandy soils, Brown Sandy Loam and Yellow-Gray Sandy Loam, are very deficient, containing only 600 and 480 pounds an acre, respectively, in the surface 2 million pounds. Yellow Silt Loam is but little better, with 640 pounds of this element. Since in the first two of these three types the phosphorus percentage is no higher in the deeper layers, not much could be expected in the way of continued high production on these soil types without phosphate fertilization. The other soils of the county range from 780 pounds an acre in Brown-Gray Silt Loam On Tight Clay to 1,860 pounds in Black Clay Loam Over Sand or Gravel. The three bottom-land types are all rather high, containing 1,640 pounds of phosphorus per 2 million pounds of surface soil.

The potassium content of the soils of Logan county is relatively uniform. Except for the two sandy types, Brown Sandy Loam and Yellow-Gray Sandy Loam, the range is from approximately 30,000 to 38,000 pounds an acre, with an average of 34,000 pounds. The two sandy types above mentioned contain only about three-fourths as much potassium as the mean of the rest of the county and have the additional handicap of carrying a considerable proportion of their potassium content in the coarse sand grains. The relatively small surface exposed in the case of the coarse particles greatly lowers the solubility and availability of the potassium in sand soils. This is partly offset by the greater depth

of the feeding zone for crop roots in sandy soils as compared with the heavier types. While the Experiment Station has carried out no field experiments in the management of either Brown Sandy Loam or Yellow-Gray Sandy Loam, it would appear from the above considerations that these are the only soil types in Logan county which would be at all likely to respond to potassium applications for the production of our common field crops; and even on these types the use of well-planned rotations, the return of crop residues and manure, and the plowing down of sweet clover will go a long way toward maintaining an adequate supply of this element in the available condition for growing crops.

The amounts of calcium and magnesium in soils usually vary greatly and this is the case in the soils of Logan county. The range in calcium content in the upper 6⅔ inches is from 4,740 pounds to 18,890 pounds in 2 million pounds of soil, while the extremes in magnesium content are even farther apart. Magnesium has never been found deficient for crop growth in the soils of Illinois, nor indeed in the United States. Calcium, however, in strongly acid soils may become available too slowly, at least for certain crops such as alfalfa and sweet clover. This is a defect which is corrected by liming.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper stratum, or with each other, it is necessary to bear in mind that the data as given for the middle and lower sampling strata are on the basis of 4 million and 6 million pounds of soil, and should therefore be divided by 2 and 3 respectively before being compared with each other or with the data for the upper stratum, which is on a basis of 2 million pounds.

Considering the data in this way it will be noted in comparing the three strata with each other that some of the elements exhibit no consistent change in amount with increasing depth. This is true particularly of potassium. Others exhibit more or less marked variation in amount at the different levels. Furthermore, these variations as a rule go in certain general directions, and by a careful study of them it is frequently possible to obtain clues as to the age or stage of maturity of the various soils and the nature of the processes going on in soil formation.

From this point of view it will be seen in comparing the three strata with each other that all of the soil types diminish rather rapidly in organic matter and nitrogen with increasing depth, and that this diminution is very marked even in the middle stratum. It should be remembered that this stratum, extending to a depth of 20 inches, includes in many cases portions of the A_2, and even of the B horizon, or subsoil. The sulfur content decreases with increasing depth in nearly all cases. This is to be expected since a portion of the sulfur exists in combination with the soil organic matter, which is more abundant in the upper strata, and since inorganic forms of sulfur are not tenaciously retained by the soil against the leaching action of ground water. Phosphorus, on the other hand, is not removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in these forms in

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF LOGAN COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES
Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 400, 900)							
226, 426, 926	Brown Silt Loam	46 250	4 410	1 020	850	35 170	7 980	9 820
420, 920	Black Clay Loam	69 970	6 220	1 460	1 120	31 930	12 490	18 890
428, 928	Brown-Gray Silt Loam On Tight Clay	33 340	3 220	780	680	29 440	4 700	6 860
260, 460	Brown Sandy Loam	18 780	2 100	600	440	27 340	4 280	5 920
	Upland Timber Soils (200, 400, 900)							
234, 434, 934	Yellow-Gray Silt Loam	20 350	2 080	860	570	35 450	3 890	6 680
235, 435, 935	Yellow Silt Loam	27 480	2 200	640	500	35 380	4 320	8 520
464	Yellow-Gray Sandy Loam	10 260	880	480	340	25 580	3 040	4 740
419	Brown Clay Loam	46 280	3 900	1 220	980	32 520	12 240	17 160
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Sand or Gravel	47 950	4 850	1 360	680	31 600	5 770	10 670
1520	Black Clay Loam Over Sand or Gravel	44 720	5 700	1 860	1 100	37 340	10 060	18 540
1566	Brown Sandy Loam Over Sand or Gravel	24 120	2 110	1 060	400	32 250	4 980	7 360
1536	Yellow-Gray Silt Loam Over Sand or Gravel	20 460	2 460	900	400	35 380	4 640	5 280
1528	Brown-Gray Silt Loam On Tight Clay	37 340	3 960	1 310	670	33 840	4 360	7 600
	Swamp and Bottom-Land Soils (1300, 1400)							
1326, 1426	Deep Brown Silt Loam	48 570	5 030	1 640	840	38 650	10 560	15 070
1320, 1420	Black Clay Loam	54 700	5 620	1 640	800	34 140	9 960	15 900
1319, 1419	Brown Clay Loam	48 540	5 500	1 640	780	35 700	10 140	16 460
1354, 1454	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]On account of the heterogenous character of Mixed Loam, chemical analyses are not included for this type.

plant residues at the expense of the underlying strata. The second stratum (6⅔ to 20 inches) furnishes a considerable proportion of the phosphorus thus moved upward, as is attested by the smaller amounts found by analysis in 12 of

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF LOGAN COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 400, 900)							
226, 426, 926	Brown Silt Loam	65 400	6 490	1 770	1 310	70 010	19 540	19 910
420, 920	Black Clay Loam	80 100	7 550	2 440	1 650	64 770	26 890	35 060
428, 928	Brown-Gray Silt Loam On Tight Clay	22 760	3 000	1 200	840	69 800	13 560	10 280
260, 460	Brown Sandy Loam	35 480	3 640	1 160	960	56 160	10 160	13 520
	Upland Timber Soils (200, 400, 900)							
234, 434, 934	Yellow-Gray Silt Loam	15 020	2 040	1 680	760	76 700	14 700	9 280
235, 435, 935	Yellow Silt Loam	23 840	2 440	1 840	680	71 800	14 640	17 240
464	Yellow-Gray Sandy Loam	13 880	1 720	1 000	360	52 440	7 000	11 360
419	Brown Clay Loam	52 200	4 920	1 720	1 280	66 840	24 320	30 480
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Sand or Gravel	72 950	7 830	2 320	1 130	66 660	14 080	20 750
1520	Black Clay Loam Over Sand or Gravel	68 400	6 600	2 960	1 520	67 240	23 400	34 880
1566	Brown Sandy Loam Over Sand or Gravel	44 160	4 030	1 490	960	61 900	11 500	14 360
1536	Yellow-Gray Silt Loam Over Sand or Gravel	16 280	2 160	1 880	520	80 720	13 080	18 080
1528	Brown-Gray Silt Loam On Tight Clay	27 220	3 620	2 100	780	71 400	8 720	13 860
	Swamp and Bottom-Land Soils (1300, 1400)							
1326, 1426	Deep Brown Silt Loam	81 500	8 860	2 960	1 360	78 700	23 720	29 440
1320, 1420	Black Clay Loam	63 320	7 520	2 480	840	72 800	18 680	28 240
1319, 1419	Brown Clay Loam	57 720	6 320	2 640	1 240	69 760	22 080	30 400
1354, 1454	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.

the 15 types in the county. The analyses indicate that the lower stratum has also contributed to some extent in this upward movement of phosphorus.

Two important basic elements, calcium and magnesium, have undergone some shifting in the different levels, as exhibited by analyses of upland types. In the surface soil the calcium content, on the whole, is much higher than that of magnesium, indicating a more abundant supply of calcium in the soil-forming materials. In the middle stratum the calcium content remains the same or diminishes as compared with the upper. The magnesium content, on the other

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF LOGAN COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES
Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 400, 900)							
226, 426, 926	Brown Silt Loam	42 830	5 440	2 330	1 400	105 050	36 870	31 400
420, 920	Black Clay Loam	46 670	5 080	3 170	1 540	97 810	47 600	76 510
428, 928	Brown-Gray Silt Loam On Tight Clay	18 660	3 120	2 820	1 320	103 320	38 640	22 920
260, 460	Brown Sandy Loam	36 420	3 600	1 740	660	84 780	25 980	47 700
	Upland Timber Soils (200, 400, 900)							
234, 434, 934	Yellow-Gray Silt Loam	14 730	2 430	2 970	870	110 820	34 200	24 390
235, 435, 935	Yellow Silt Loam	19 080	2 400	2 700	720	95 940	23 040	22 020
464	Yellow-Gray Sandy Loam	13 140	1 560	1 560	1 140	83 280	11 340	16 140
419	Brown Clay Loam	43 020	4 080	2 880	900	100 680	42 600	46 680
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Sand or Gravel	49 290	5 430	3 030	1 190	98 490	26 900	29 690
1520	Black Clay Loam Over Sand or Gravel	39 420	4 560	3 840	1 320	101 520	39 240	40 980
1566	Brown Sandy Loam Over Sand or Gravel	29 250	2 860	1 460	840	94 330	17 740	19 900
1536	Yellow-Gray Silt Loam Over Sand or Gravel	17 580	2 880	3 420	900	117 900	23 880	27 120
1528	Brown-Gray Silt Loam On Tight Clay	18 570	3 420	3 150	780	105 600	21 570	22 740
	Swamp and Bottom-Land Soils (1300-1400)							
1326, 1426	Deep Brown Silt Loam	87 660	8 520	3 780	1 770	114 120	32 700	42 030
1320, 1420	Black Clay Loam	55 860	6 120	3 240	840	100 680	29 520	39 900
1319, 1419	Brown Clay Loam	41 160	4 740	3 360	1 620	108 360	33 660	42 360
1354, 1454	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.

hand, increases in both the middle and lower strata. These two elements are unequally removed from the soil by leaching, the calcium being dissolved and carried downward to a greater extent than magnesium. Consequently the magnesium content tends to become high in the middle and lower strata, while the calcium content of the lower sampling strata is, on the average, little or no higher than the upper. This spread between these two elements in the lower depths is greatest in soils of extreme maturity and cannot be observed at all in soils so young as to show indistinct stratification. In line with this idea it would

appear that Logan county soils are, for the most part, in youth and middle age, none being in extremely advanced stages.

Potassium, another important basic plant-food element, is present in much larger amounts than either calcium or magnesium, and does not exhibit any marked variation in amount in the different depths. Wherever any differences do occur, they are only slight considered in proportion to the total amounts present.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is not possible to obtain this information exactly, especially for the deeper-rooted crops, it seems probable that practically all of the feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil type the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

Examining the data in this manner the tables reveal that there is not only a wide diversity among the different soils with respect to a given plant-food element, but that there is also a great variation with respect to the relative abundance of the various elements within a given soil type as measured by crop requirements. For example, in one of the most extensive soil types in the county, Brown Silt Loam, Upland, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 16,340 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus, 5,120 pounds, contained in the same soil is equivalent to that contained in 30,100 bushels of corn, while in the same quantity of this soil there is present 210,230 pounds of potassium, the equivalent of that contained in more than one million bushels of corn. In marked contrast to this soil, Yellow-Gray Silt Loam, an important upland timber soil type, contains in the 40- inch stratum less than one-half as much nitrogen, or 6,550 pounds per acre, an amount equal to that in 6,550 bushels of corn. The phosphorus content of Yellow-Gray Silt Loam is slightly higher than that of Brown Silt Loam, namely, 5,510 pounds in an acre, which is equivalent to that contained in 32,400 bushels of corn. The potassium content is about the same as in Brown Silt Loam.

In the case of calcium the legumes utilize and remove from the soil much larger quantities than do the grain crops, and the comparisons will therefore be of more interest if one of these crops is used. A ton of red clover contains approximately 29 pounds of calcium, while 100 bushels of corn contain only about one pound of this element. The 61,130 pounds of calcium in the 40-inch depth of Brown Silt Loam, therefore, are equivalent to that in 2,100 tons of red clover hay, while that in Yellow-Gray Silt Loam is only two-thirds as high, namely, 40,350 pounds, or the equivalent of 1,400 tons of the same hay.

It is obvious from the above comparisons that the outstanding differences between these two important soil types, so far as chemical composition is concerned, lie in their calcium, nitrogen, and organic matter.

These considerations are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate

procedure to be followed in the improvement of a soil, for other factors enter into consideration, aside from merely the amount of plant-food elements present. Much depends upon the nature of the crops to be grown, in their utilization of plant-food materials, and much depends upon the availability of the plant-food substances. Finally, in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures, do, however, furnish an inventory of the total stocks of the plant-food elements that can possibly be drawn upon, and in this way contribute fundamental information for the intelligent planning, in a broad way, of systems of soil management for conserving and improving the fertility of the land.

DESCRIPTION OF SOIL TYPES

UPLAND PRAIRIE SOILS

The upland prairie soils of Logan county occupy 454.86 square miles, or nearly three-fourths of the area of the county. The dark color of the prairie soils is due to the accumulation of organic matter which is derived, very largely, from the fibrous roots of the prairie grasses. The network of grass roots which once covered these areas was protected from rapid and complete decay by the covering of fine, moist surface soil and by the mat of vegetative material formed by the debris of the dead leaves and stems. On the native prairies the stems and leaves were usually burned in part by prairie fires or disappeared in part by decay. This surface accumulation, which was constantly renewed, added but little organic matter to the soil directly, but the decay of the prairie-grass roots was retarded considerably by it.

The upland prairie soils in this county include some areas of recent timber growth, where certain kinds of trees have spread over the prairie, but this forestation has not been of sufficient duration to produce the characteristic timber soils. These areas of greater or less width are found along the border of most timber tracts, so that the timber actually extended a little farther than the soil would indicate.

Brown Silt Loam (226, 426, 926)

Brown Silt Loam, as it is mapped in Logan county, occupies nearly 370 square miles, or about 60 percent of the area of the county. It varies in character depending on topography. Three divisions of the type as mapped are recognized at the present time. Each of these is described below so that it may be recognized in the field.

1. Light Brown Silt Loam. This type occurs on the higher areas and on slopes where the surface drainage is good. The A_1 horizon, or surface, is about 7 inches thick and is a light brown silt loam, frequently having a yellowish cast. The A_2 horizon, or subsurface, extending to a depth of about 18 inches, is a yellowish brown silt loam. The B horizon, or upper subsoil, is a friable, non-mottled, dark reddish yellow silty clay loam. The C horizon, or lower subsoil,

which is found at a depth of about 36 inches, is a very friable, slightly mottled silt loam or fine sandy loam.

Management.—The character of the profile of Light Brown Silt Loam, together with its topographic position, affords perfect surface and underdrainage. Some care must be exercised in preventing erosion, as many of the slopes are steep enough to allow rapid runoff if the surface is bare. This soil is not as high in organic matter and nitrogen as it should be and it is usually medium acid. Limestone should be applied at the rate of 2 to 3 tons an acre, and clover grown every 3 or 4 years as a source of organic matter and nitrogen. The best information available on the treatment of this type comes from the Mt. Morris experiment field which is located in part on Light Brown Silt Loam. The results from this field show a very marked response to manure. Where limestone was applied in addition to manure, a further increase was secured which was sufficiently large to pay a good profit on the cost of the limestone. Another treatment which gave very good increases on this field was residues and limestone used in combination. Potash has not increased the yields on this field. Rock phosphate when used in addition to manure has not increased yields, and when used in addition to residues, the yields have been increased just about enough to pay for applying half a ton of rock phosphate per acre once in the rotation. For further description of the Mt. Morris field, including the data, see page 40.

2. **Brown Silt Loam.** This type occupies intermediate topographic positions. It differs from the preceding type, Light Brown Silt Loam, in having a darker and usually thicker A_1 horizon, or surface, a less yellow A_2 horizon, or subsurface, and a heavier, less friable, and somewhat mottled B horizon, or upper subsoil.

Management.—Brown Silt Loam is somewhat less acid than Light Brown Silt Loam but requires limestone to grow alfalfa or sweet clover. It was originally well supplied with organic matter and has been subject to but little loss of soil material thru erosion. The Kewanee experiment field is located, for the most part, on this soil type. A description of the work on this field, including the experimental data, will be found on page 42. Unfortunately, the Kewanee field has several draws crossing the plots which are a much heavier soil, so that the results from the field cannot be applied to Brown Silt Loam with as much confidence as would otherwise be the case. It is almost certainly true, however, that the presence of the heavier type on the Kewanee field has the effect of diminishing the increases due to treatment. This field shows very good results for manure on corn and oats, but less effect on wheat. Limestone has given profitable increases, particularly in the residues system. Rock phosphate has increased the yield of wheat on the manure plots by 5.5 bushels, but has had little or no effect on the other crops in the rotation. On the residues plots, rock phosphate has caused very satisfactory increases in the yield of corn, oats, and wheat, but has had little effect on the yield of clover hay. A comparison of rock and acid phosphate on the Kewanee field, which has been in progress too short a time to allow final conclusions, suggests that better results might be secured on this soil type with acid phosphate than with rock phosphate. This

tentative suggestion is strengthened by the results from the Bloomington field (see page 44), which is located in part on this soil type. Steamed bone meal has been used as the source of phosphorus on this field and the increases caused by its use have been very striking. The only concrete suggestion for the phosphate fertilization of this soil type which can be made at the present time is to make a trial of one of the more available forms of phosphates, applying it for the wheat crop.

3. **Brown Silt Loam on Clay.** This type occupies the nearly level or only gently sloping areas in the upland prairie region. It is characterized by a dark brown A_1 horizon, or surface, about 9 inches thick and a brown A_2 horizon, or subsurface, containing pale yellow spots. The B horizon, or upper subsoil, is usually a strongly mottled, brownish yellow, somewhat compact and plastic, clay loam. At a depth of 32 to 40 inches, the more friable C horizon, or lower subsoil, is found.

Management.—This type is either not acid or only slightly so. The subsoil, while more compact and plastic than that under either of the preceding types discussed, drains well with tile. The Aledo experiment field is located on Brown Silt Loam On Clay and the results from this field may be used as a guide in the treatment of this soil type in Logan county. Manure has given very good returns. Limestone has failed to give very convincing increases and its indiscriminate use could hardly be advised on this soil unless alfalfa or sweet clover is to be grown. Rock phosphate has not caused increases in yield on the manure plots but its use on the residues plots has resulted in sufficiently large increases to justify advising its use when manure is not available. Phosphate comparisons have been in progress on the Aledo field since 1916 and the reader is asked to turn to page 45 of the Supplement to this Report and make a study of the results as an aid in solving his phosphate problem on Brown Silt Loam On Clay.

Black Clay Loam (420, 920)

Black Clay Loam is extensively developed in Logan county, occupying all told nearly 84 square miles, or about 13½ percent of the total area of the county. The A_1 horizon, or surface, which is about 10 inches thick, is black clay loam. The A_2 horizon, or subsurface, is 9 or 10 inches thick. It is drabbish black clay loam. The B horizon, or upper subsoil, varies considerably. In some places it is a deep heavy gray clay, and in others, drab clay resting on very friable yellow fine sandy loam. The pond, or alluvial, formation of this type explains the subsoil variations.

Management.—Black Clay Loam rarely needs limestone to grow sweet clover. Some areas of the type contain sufficient alkali to be harmful. It is a productive soil and needs no treatment other than fresh organic matter to help keep it in good physical condition. Clover should be grown every third or fourth year and turned under directly or as manure. The reader is asked to turn to page 50, where the results and discussion of the Hartsburg experiment field, which is located on this soil type, will be found.

Brown-Gray Silt Loam On Tight Clay (428, 928)

Brown-Gray Silt Loam On Tight Clay, Upland, is a minor type in Logan county, aggregating only 250 acres. The reader is referred to page 20, where a description of Brown-Gray Silt Loam On Tight Clay, Terrace, will be found. The two types as developed in Logan county are identical except in origin.

Brown Sandy Loam (260, 460)

Brown Sandy Loam is a minor type in Logan county. It occurs as small areas in the northwestern part of the county and aggregates only 1.15 square miles. The dune-like topography of the region where this type occurs suggests its wind origin and the nearness of the sandy terrace on the west also suggests the same origin. The A_1 horizon, or surface, to a depth of 7 or 8 inches is a light brown sandy loam. Below this depth the color changes gradually from yellowish brown to yellow and the texture becomes coarser. The areas which have been undisturbed by the wind for a long period of time have developed a finer texture and some compaction in the subsoil.

Management.—The occurrence of this type in small areas makes it usually necessary to crop this soil in the same way that the adjacent land is cropped. It is possible, however, to provide for larger additions of leguminous organic matter and manure than are given to the adjacent silt loams and clay loams. Limestone should be applied at the rate of about 2 tons an acre, and sweet clover should be grown once in the rotation. The sweet clover can well be utilized by plowing it down in the spring of the second year for corn. No mineral fertilizer treatment is advised except on a trial basis.

UPLAND TIMBER SOILS

The upland timber soils are not extensively developed in Logan county. They cover only about 42 square miles, or less than 7 percent of the area of the county. They occur adjacent to most of the streams. They are usually characterized by a yellow or yellowish gray color, which is due to the low organic-matter content. This lack of organic matter has been caused by the long-continued growth of forest trees. As the forests invaded the prairies, the following effects were produced: the shading of the trees prevented the growth of grasses, the roots of which are mainly responsible for the large amount of organic matter in the prairie soils; and the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed or were destroyed by forest fires. The timbered soils are divided into two groups, the undulating and the eroded.

Yellow-Gray Silt Loam (234, 434, 934)

Yellow-Gray Silt Loam as shown on the soil map occurs most extensively in the south-central, west-central, and north-central parts of the county. It aggregates a total of about 36 square miles and is by far the most important light-colored or timber soil in the county. The A_1 horizon, or surface, is a brownish gray silt loam and varies from 6 to 8 inches in thickness. The A_2

horizon, or subsurface, varies from 6 to 8 or 10 inches in thickness and is a yellowish gray or grayish brown silt loam. The B horizon, or upper subsoil, varies in compactness, color, and thickness. In the rolling areas it is reddish brown, in the flat areas, drabbish, and on intermediate topography it is pale yellow with gray mottling.

Management.—In the above description of Yellow-Gray Silt Loam no attempt was made to describe the different kinds of Yellow-Gray Silt Loam which occur in Logan county and to point out their correlation with topography. In planning the management of this type, however, attention should be paid to differences in the type, particularly with reference to the subsoil. The rolling areas have a pervious subsoil but because of their topography are subject to erosion. They should be cropped in such a way as to have a vegetative cover on the land as much of the time as possible. The more gentle slopes have a less pervious subsoil but are not subject to serious erosion if reasonable care is taken to control it. The flat areas have a relatively impervious subsoil, tho not so impervious that tile will not draw. Drainage of these flat areas, however, must be effected in part by surface ditches and open furrows. The type as a whole is acid and limestone should be applied. The flat areas are usually more acid than the rolling ones. All phases of the type are low in nitrogen and organic matter. These constituents should be secured by growing clover, preferably sweet clover, and plowing it down in the spring of the second year for corn. No experiment field data are available upon which to base fertilizer recommendations, but it is suggested that one or more of the phosphates be tried, particularly for the wheat crop. See "The Phosphorus Problem," page 32.

Yellow Silt Loam (235, 435, 935)

Yellow Silt Loam is a minor type in Logan county because of its small total acreage, less than 6 square miles, and because of its relatively low agricultural value. The character of this type varies, depending largely on the rapidity of erosion. In places a shallow surface soil has been developed, while in other places the removal of the soil material by erosion is more rapid than the development of the soil horizons.

Management.—Yellow Silt Loam should, for the most part, be used for permanent pasture, orchard, or timber. There are areas having a slope sufficiently gentle to be farmed successfully if care is taken to reduce erosion to the minimum. A very good use to make of the less steep slopes is to seed alfalfa after applying limestone. If the alfalfa is preceded by sweet clover, little difficulty should be encountered in getting a stand.

Yellow-Gray Sandy Loam (464)

Yellow-Gray Sandy Loam is a very minor type in Logan county, totaling less than a hundred acres. It may be handled in the same way as Brown Sandy Loam (see page 17).

Brown Clay Loam (419)

Brown Clay Loam, Upland, is a shallow lake or pond formation. The moisture conditions during its development have been such that the organic matter has decayed without the formation of the black pigments; consequently a brown rather than a black soil has resulted. There are about 250 acres of Brown Clay Loam in the upland in Logan county.

The A_1 horizon, or surface, is about 8 inches thick and is a brown clay loam. The A_2 horizon, or subsurface, extends to a depth of about 19 inches and is a drabbish brown clay loam. The B horizon, or upper subsoil, is a medium compact, medium plastic, brownish drab clay loam. It contains many pale yellow and reddish brown spots. The C horizon, or lower subsoil, is a medium friable, drab and pale yellow clay loam.

Management.—This soil should be handled in the same way as Black Clay Loam, Upland (see page 16). It is a productive soil and, so far as is known, does not contain alkali in harmful amounts.

TERRACE SOILS

Relatively small areas of terrace soils occur in Logan county. These soils were formed in remote times by overloaded and flooded streams which deposited an immense amount of material in the old channels. Later as the streams diminished in size or cut their channels deeper, new bottoms were developed, leaving the old flood plains above overflow, thus forming terraces.

These terrace formations which were built up, for the most part, during and immediately following the Glacial period, were later covered to varying depths with wind-blown material from which the present soils were formed.

Brown Silt Loam Over Sand or Gravel (1527)

Brown Silt Loam Over Sand or Gravel is the most important terrace type in Logan county. It covers a little over 38 square miles and is a productive soil. It is very similar to Brown Silt Loam On Clay, Upland, except in origin. See page 16 for the description of that type and for suggestions regarding its management.

Black Clay Loam Over Sand or Gravel (1520)

Black Clay Loam Over Sand or Gravel occupies a little over 4 square miles in Logan county. It differs in no essential, except in origin, from Black Clay Loam, Upland. See page 16 for a description of that type and for suggestions regarding its management.

Brown Sandy Loam Over Sand or Gravel (1566)

Brown Sandy Loam Over Sand or Gravel is a minor type in Logan county, occupying only one-third of a square mile. It is very similar to Brown Sandy Loam, Upland, except in origin, and the reader is asked to turn to the discussion of that type, page 17.

Yellow-Gray Silt Loam Over Sand or Gravel (1536)

Yellow-Gray Silt Loam Over Sand or Gravel is similar to the flat Yellow-Gray Silt Loam, Upland. The underlying sand or gravel is sufficiently deep not to cause a drouthy condition, and yet its presence improves the underdrainage. Limestone should be supplied and clover grown as is suggested for Yellow-Gray Silt Loam, Upland (page 17).

Brown-Gray Silt Loam On Tight Clay (1528)

Brown-Gray Silt Loam On Tight Clay, Terrace, occurs for the most part along Deer creek northwest of the village of Beason. It occupies a total of 5.72 square miles in Logan county. It is important to note the characteristics of this type carefully, as it resembles Brown Silt Loam, Terrace, very closely in the surface and is often mistaken for it.

The A_1 horizon, or surface, to a depth of 8 or 9 inches is a grayish brown silt loam which may entirely lose its gray cast when moist. The A_2 horizon, or subsurface, is gray silt loam and extends to a depth of 18 or 20 inches. Immediately below the gray subsurface layer or horizon, the plastic, heavily mottled tight clay B horizon, or upper subsoil, is found. This horizon extends to a depth of about 36 inches and rests on a gray, more friable, C horizon. Some areas of this type do not correspond to the above description in that the tight clay horizon is much deeper because of silting in. These deeper areas, while not separated out on the map, are better soil because of the greater depth of the tight clay.

Management.—Brown-Gray Silt Loam, Terrace, varies in its need for lime, some areas showing no acidity at all, while others need 2 to 3 tons of limestone an acre. Before applying limestone, each field should be tested in detail with the assistance of the county farm adviser or the Agricultural Experiment Station. Underdrainage is not effective on this type except on the areas in which the tight clay lies below the depth at which the tile are placed. Surplus water must be removed by open furrows and ditches. Sweet clover grows well on this soil and improves very materially the grain crops that follow it. No fertilizer applications, except manure, are advised for this type until the nitrogen and organic-matter contents of the soil are increased by means of legumes.

SWAMP AND BOTTOM-LAND SOILS

This group includes the bottom lands along the creeks of the county. These bottoms were formed at a time when the creeks carried much more water than they do at the present time. Much of this land is subject to overflow. On the soil map, the Swamp and Bottom-Land Soils are divided into two groups but these groups are combined into one in the following descriptions for the reason explained on page 4.

Deep Brown Silt Loam (1326, 1426)

Deep Brown Silt Loam is a productive soil, easily worked, and where subject to overflow is non-acid. It is a young, immature soil, and has not developed distinct horizons. The surface is a brown to dark brown silt loam, frequently

16 or even 18 inches thick. Below this dark-colored surface, the color gradually assumes a drabbish cast with increasing depth. Often at a depth of 36 to 40 inches it becomes gray, showing a high water table.

Management.—Deep Brown Silt Loam requires no fertilizer treatment other than the plowing down of legumes, particularly on the non-overflow areas, and the use of limestone where acidity has developed.

Black Clay Loam (1320, 1420)

A total of 12 square miles of Black Clay Loam, Bottom, occurs in Logan county. It is found in situations where the rate of flow of the sediment-carrying current was so slow that only fine particles could be carried and deposited. The surface is black clay loam, averaging about 10 inches thick. The subsurface and subsoil are not distinctly developed because of the youth or immaturity of the soil. Below 10 inches the color becomes intensely drab and changes to gray or grayish drab at about 26 inches.

Management.—Black Clay Loam, Bottom, is productive but rather difficult to work because of its fine texture. Fresh organic matter should be plowed down frequently to keep the soil in a workable condition. Limestone is usually not needed.

Brown Clay Loam (1319, 1419)

Brown Clay Loam, Bottom, occurs in the southern part of the county along Lake fork of Salt creek. The reason for its development rather than the development of Black Clay Loam is not clear. The surface soil to a depth of about 12 inches is a brown clay loam. The subsurface and subsoil horizons are not well defined because of the youth of the soil. The subsurface is a drabbih brown clay loam and extends to a depth of about 20 inches. The subsoil is a drab clay loam with reddish brown spots and is medium plastic and compact. No change in the character of the subsoil is apparent within the 40-inch section.

Management.—Brown Clay Loam, Bottom, is a productive soil, easier to work than Black Clay Loam, Bottom, and for the present needs nothing more than the plowing down of fresh organic matter at frequent intervals, together with improvement in drainage.

Mixed Loam (1354, 1454)

Mixed Loam, Bottom, is of alluvial origin and is very diverse in character. It consists of distinct types occurring in such small areas that they cannot be shown on the map and consequently they are all grouped together and called Mixed Loam. The texture of the surface varies from a sandy loam to a clay loam. The subsurface and subsoil vary in the same way as does the surface. There are a little more than 7 square miles of Mixed Loam in this county.

Management.—The diversity of Mixed Loam calls for different tillage methods where the extremes in the type occur. Some areas are so heavy as to require care in working them at the right moisture content, while others are very sandy. The type in general is not acid and needs only fresh organic matter and intelligent tillage.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items, such as native vegetation (whether timber or prairie), topography, and geological origin and formation, may assist in the differentiation of types, altho they are not fundamental to it.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a matured soil, three horizons designated as A, B, and C are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the A horizon.

C designates the layer lying below the B horizon and in which the material has been less affected by the weathering processes.

Frequently differences within a stratum or zone are discernible, in which case it is subdivided and described under such designations as A_1, and A_2, B_1, and B_2, etc.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in differentiating soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of this report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation

1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* formed by material derived from the Illinoisan or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction.

Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5.
[2]Young second-year growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface $6\frac{2}{3}$ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than

do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should

be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4, have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of mod-

erate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogeneous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, acid phosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate, and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the

oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average livestock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible

to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical

condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop be corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the better adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year—Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year—Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed; or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

The two following rotations are suggested as especially adapted for combating the corn borer:

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Corn (for silage)
Sixth year —Wheat (with sweet clover)

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Wheat (with alfalfa)
Sixth year —Alfalfa

Five-Year Rotations

First year —Corn
Second year—Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year—Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year—Soybeans
Third year —Corn
Fourth year—Wheat (with legume)
Fifth year —Legume

First year —Corn
Second year—Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year—Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field rotating over all fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute barley or rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover, or it may include alfalfa used as a biennial. The mixing of alfalfa with clover seed for a legume crop is a recommendable practice. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to those Occurring in Logan County)

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system. Some modifications have been introduced in recent years.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grain to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated (aP = acid phosphate, bP = bonemeal, rP = rock phosphate, sP = slag phosphate)
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
Le = Legume used as green manure
Cv = Cover crop
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed
| = Heavy vertical rule, indicating the beginning of complete treatment
|| = Double vertical rule, indicating a radical change in the cropping system

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

THE MT. MORRIS FIELD

The Mt. Morris experiment field lies mainly on the soil type Light Brown Silt Loam. This field is located in about the center of Ogle county immediately south of the town of Mt. Morris. The experiments on the major series of plots have been under way since 1910.

The somewhat standard rotation and soil treatment methods described above were established on Series 100, 200, 300, and 400. In 1920 a clover hay crop, as well as the seed crop, was harvested from the residues plots. Beginning with

1921 all clover was removed as hay and the return of the oat straw discontinued. In 1922 the return of the wheat straw was discontinued, as well as the applications of limestone until such time as its need should become apparent. In 1923 the rock phosphate applications were evened up to 4 tons an acre and no more will be applied for an indefinite period. A summary of the results is given in Table 7.

TABLE 7.—MT. MORRIS FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1913-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *14 crops*	Oats *14 crops*	Wheat *12 crops*	Clover[1] *10 crops*	Soybeans *2 crops*
1	0	45.3	58.5	23.3	(1.96)	(1.56)
2	M	59.5	67.4	28.1	(2.53)	(1.70)
3	ML	64.4	70.5	34.4	(2.97)	(1.80)
4	MLP	64.3	71.5	35.9	(2.92)	(1.92)
5	0	44.6	54.9	23.5	(1.61)	13.5
6	R	51.2	59.4	25.8	(1.77)	16.0
7	RL	62.2	68.8	32.7	(2.24)	18.9
8	RLP	65.6	70.2	36.2	(2.23)	20.7
9	RLPK	67.2	70.4	36.3	(2.24)	20.0
10	0	43.6	52.4	24.6	(1.79)	(1.68)
	Crop Increases					
	M over 0	14.2	8.9	4.8	(.57)	(.14)
	R over 0	6.6	4.5	2.3	(.16)	2.5
	ML over M	4.9	3.1	6.3	(.44)	(.10)
	RL over R	11.0	9.4	6.9	(.47)	2.9
	MLP over ML	— .1	1.0	1.5	—(.05)	(.12)
	RLP over RL	3.4	1.4	3.5	—(.01)	1.8
	RLPK over RLP	1.6	.2	.1	(.01)	— .7

[1]Some clover seed evaluated as hay.

The outstanding results from these records are those produced by the manure treatment. Over 14 bushels of corn, nearly 9 bushels of oats, 4.8 bushels of wheat, and a half ton of clover hay have been the average annual acre increases in crop yields from the manure plots over the corresponding checks. Residues alone have also produced increases in the crop yields altho the effect is much less pronounced than that of manure alone.

Limestone has been profitably used in both the manure and residues systems but the benefit has been greater in the residues system.

The rock phosphate, as usual, has been somewhat more effective used with residues than with manure, but under present market conditions it has thus far not returned its cost, even with residues. However, as noted above, applications of phosphate have been suspended and the residual effect of the accumulated phosphorus in the soil during the years to come will be awaited with interest.

No significant effect is apparent from potassium as used in these experiments.

FIG. 2.—CORN ON THE MT. MORRIS FIELD

The two pictures represent the extremes in corn production according to soil treatment. Where the untreated land has produced as a fourteen-year average 44.6 bushels an acre, the land under the residues, limestone, phosphate, potash treatment has yielded 67.2 bushels. The most profitable treatment on this field, however, has been that of residues and limestone, which has produced 62.2 bushels an acre.

THE KEWANEE FIELD

The Kewanee field represents in the main the soil type Brown Silt Loam, altho a draw traversing the field in a winding direction contains a narrow streak of a heavier type designated as Black Clay Loam On Drab Clay. The Kewanee field has been in operation since 1915. The crops grown on the main series of plots are wheat, corn, oats, and clover. The arrangement of plots as well as the systems of soil treatment are indicated in Table 8.

The table gives a summary of the crop yields by annual averages, including the years since the complete soil treatments have been in effect. In the lower part of the table the comparisons expressed as crop increases resulting from the respective soil treatments bring out the following points of interest.

Animal manure used alone has had a very beneficial effect, especially with corn, oats, and clover. Residues alone has had little effect on crop yields.

Limestone used in addition to organic manures has effected more or less improvement in all cases except where used with animal manure on the clover.

Phosphorus, as usual, shows up to advantage on the wheat crop, and in the residues system the rock phosphate has produced a profitable return. A fact which these general averages fail to show is that with both limestone and phosphate the effects have been more favorable in recent years than in the earlier years of the experiments.

Altho an increase of 3.3 bushels of corn appears as a result of potassium application, in view of the insignificant response by the other crops the purchase of potassium fertilizer for use in this kind of a cropping system on this kind of soil would appear not to be profitable.

TABLE 8.—KEWANEE FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1917-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *8 crops*	Corn *10 crops*	Oats *10 crops*	Clover *9 crops*
1	0	30.2	54.4	58.8	(1.65)
2	M	33.0	64.9	69.5	(2.26)
3	ML	35.9	68.8	72.1	(2.26)
4	MLP	40.6	69.7	70.8	(2.33)
5	0	31.4	55.8	59.6	(1.55)
6	R	33.0	57.9	58.0	(1.59)
7	RL	35.1	66.1	62.2	(1.84)
8	RLP	40.6	70.1	67.6	(2.01)
9	RLPK	40.6	73.4	69.3	(2.08)
10	0	29.7	51.0	55.3	(1.53)
	Crop Increases				
	M over 0	2.8	10.5	10.7	(.61)
	R over 0	1.6	2.1	− 1.6	(.04)
	ML over M	2.9	3.9	2.6	(.00)
	RL over R	2.1	8.2	4.2	(.25)
	MLP over ML	4.7	.9	− 1.3	(.07)
	RLP over RL	5.5	4.0	5.4	(.17)
	RLPK over RLP	0.0	3.3	1.7	(.07)

The Phosphate Experiments

In addition to the above described experiments on the Kewanee field, there are four shorter series of plots numbered 500, 600, 700, and 800, each series having four plots. Alfalfa was grown on these series until 1922, when a rotation of wheat, corn, oats, and clover was started. Limestone had been applied to this land at the beginning. The quantity was 4 tons an acre and a similar dressing was applied in 1919. Rock phosphate was applied to Plots 1 and 3 at the annual rate of 400 pounds an acre, once in the rotation ahead of the wheat. Acid phosphate was used on Plots 2 and 4 at the annual rate of 200 pounds an acre, it being applied twice in the rotation, one-half in preparation for wheat, and one-half before oats seeding.

Table 9 gives a summary of the results obtained to date in terms of average annual crop yields and also the corresponding values of the crops figured at average farm prices for the years in which these crops were produced. The relative profits, of course, will depend upon the market prices of the rock phosphate

TABLE 9.—KEWANEE FIELD, SERIES 500, 600, 700, 800: PHOSPHATE EXPERIMENT
Average Annual Acre Yields and Corresponding Money Values, 1922-1926

Soil treatment	Wheat *5 crops*	Corn *5 crops*	Oats *5 crops*	Hay *5 crops*	Value per acre
Rock phosphate	44.5	74.4	74.6	3.46	$45.63
Acid phosphate	47.3	73.2	77.6	3.39	46.30
Lime, rock phosphate	40.5	71.8	73.0	3.32	43.33
Lime, acid phosphate	48.1	73.1	75.1	3.40	46.32

and acid phosphate. Acid phosphate usually costs about twice as much, ton for ton, as rock phosphate, and in these experiments one-half as much acid phosphate as rock phosphate was used. If, then, it is considered that equal costs are involved, acid phosphate would appear to have been somewhat more profitable than rock phosphate, especially when used with limestone and disregarding any value for the extra amount of the element phosphorus added to the soil in the use of rock phosphate. It should be borne in mind that a change of market prices, either of materials or of produce, might easily alter these results even to the extent of reversing them.

THE BLOOMINGTON FIELD

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat; and, since 1905, they have been grown in the sequence named.

On account of irregularities in the land, results from Plots 1 and 10 are not considered altogether reliable, and therefore, are not included in the figures presented. Since these are the only unlimed plots, no conclusions can be drawn regarding the action of limestone on this field.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. The phosphorus on this field has been applied in the form of steamed bone meal and at the rate of 200 pounds an acre a year.

Table 10 presents a summary of the work by annual average yields. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they have been applied.

The residues treatment, supplying organic matter and nitrogen, shows a beneficial effect on the grain crops, but not on the clover. The outstanding feature of the results on the Bloomington field is the effect of phosphorus applied in the form of steamed bone meal. In all of the grain crops on every plot where bone meal has been applied there is a remarkable response to the treatment as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues with limestone, residues, and phosphorus) we find the phosphorus treatment has produced an average increase in the yield of corn of about 13 bushels an acre, while the yield of oats has been increased by about 20 bushels, and that of wheat by about 22 bushels an acre. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8 where potassium instead of residues is present.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is distinctly a limiting factor in production and the application

TABLE 10.—BLOOMINGTON FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields of Grain Crops 1902-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*	Clover[1] *3 crops*
2	L	41.5	44.7	24.1	(.80)
3	LR	47.5	46.2	27.9	(.88)
4	LbP	55.8	54.3	45.7	(2.54)
5	LK	46.2	43.5	25.5	(.90)
6	LRbP	60.6	66.0	49.7	(1.19)
7	LRK	48.6	46.8	27.5	(.82)
8	LbPK	60.9	57.2	44.5	(2.44)
9	LRbPK	64.2	63.1	50.4	(.81)
	Crop Increases				
For Residues					
LR	over L	6.0	1.5	3.8	(.08)
LRbP	over LbP	4.8	11.7	4.0	−(1.35)
LRK	over LK	2.4	3.3	2.0	−(.08)
LRbPK	over LbPK	3.3	5.9	5.9	−(1.63)
For Phosphorus					
LbP	over L	14.3	9.6	21.6	(1.74)
LRbP	over LR	13.1	19.8	21.8	(.31)
LbPK	over LK	14.7	13.7	19.0	(1.54)
LRbPK	over LRK	15.6	16.3	22.9	−(.01)
For Potassium					
LK	over L	4.7	− 1.2	1.4	(.10)
LRK	over LR	1.1	.6	− .4	−(.06)
LbPK	over LbP	5.1	2.9	− 1.2	−(.10)
LRbPK	over LRbP	3.6	− 2.9	.7	−(.38)

[1]Two crops of seed on Plots 3, 6, 7, and 9 evaluated as hay.

of this element in the form of steamed bone meal is attended by a high financial profit. It is of extreme interest to know whether a similar response would follow the use of other phosphorus carriers, such as rock phosphate and acid phosphate. Experiments are now under way designed to answer this question, but they have not been running long enough to furnish reliable results at the present time.

Quite different are the results from the use of potassium on this field. The potassium has been applied mainly in the form of potassium sulfate, but in 1917 when this material became unavailable thru war conditions, potassium carbonate was substituted. There is a moderate increase in the corn yield where potassium has been used and particularly where residues are absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

THE ALEDO FIELD

An experiment field on Brown Silt Loam On Clay is located in Mercer county just west of Aledo. This field has been in operation since 1910. From its physical aspects this field should be well adapted to experimental work, the land being unusually uniform in topography and in soil profile.

There are two general systems of plots and they are designated as the major and the minor systems.

Experiments on the Major Series

The major system comprizes four series (numbered 100, 200, 300, and 400) made up of 10 plots each. The plots were handled substantially as described above for standard treatment until 1918, when it was planned to harvest the first crop of red clover on the residues plots for hay and to plow down the second crop if no seed were formed. In 1921 the return of the oat straw was discontinued. In 1923 the rotation was changed to corn, corn, oats, and wheat. In this rotation it was planned to seed hubam clover in the oats on all plots, for use as hay or for soil improvement, and common sweet clover in the wheat on the residue plots for use as a green manure. Since this change, no residues except cornstalks and the green manure have been returned to the residues plots. The limestone applications were temporarily abandoned in 1923. No more will be applied until there appears to be a need for them. The phosphate applications were evened up to a total of 4 tons an acre in 1924, and no more will be applied on the west halves of these plots for some time at least.

Table 11 presents a summary of the results showing the average annual yields obtained for the period beginning when complete soil treatment came into sway. The lower section of this table gives comparisons in terms of crop increases intended to indicate the effect of the different fertilizing materials applied.

In looking over these results we may observe first the beneficial effect of animal manure on all crops, but especially marked on the corn. This suggests the advisability of carefully conserving and regularly applying all stable manure produced on the farm. Residues alone have been beneficial for corn but have shown little effect on the other crops of the rotation.

TABLE 11.—ALEDO FIELD: GENERAL SUMMARY OF CROP YIELDS
Average Annual Yields 1912-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *12 crops*	Corn *19 crops*	Oats *14 crops*	Clover *6 crops*	Soybeans *3 crops*
1	0	30.1	57.2	57.9	(2.21)	(1.60)
2	M	34.5	71.1	64.5	(2.74)	(1.63)
3	ML	34.6	74.3	67.6	(3.12)	(1.60)
4	MLP	36.6	75.6	68.2	(3.05)	(1.61)
5	0	30.8	60.1	59.7	(2.00)	16.1
6	R	31.4	66.5	61.2	(1.91)	16.5
7	RL	33.5	71.9	66.5	(1.96)	18.8
8	RLP	38.0	74.4	68.0	(2.08)	20.3
9	RLPK	37.3	76.0	70.3	(1.73)	20.9
10	0	30.1	58.3	58.1	(2.38)	(1.62)
	Crop Increases					
	M over 0	4.4	13.9	6.6	(.53)	(.03)
	R over 0	.6	6.4	1.5	−(.09)	.4
	ML over M	.1	3.2	3.1	(.38)	−(.03)
	RL over R	2.1	5.4	5.3	(.05)	2.3
	MLP over ML	2.0	1.3	.6	−(.07)	(.01)
	RLP over RL	4.5	2.5	1.5	(.12)	1.5
	RLPK over RLP	− .7	1.6	2.3	−(.35)	.6

Limestone added to the manure treatment produces no very marked effect; when applied with residues, however, the crop increases are considerably greater.

The addition of rock phosphate to the treatment has had very little effect in the manure system. Somewhat more favorable are the results in the residues system, but even here the margin of profit on these crop increases is too narrow to assure the profitable use of rock phosphate applied in the manner of these experiments. However, the economic story has not all been told, for the application of lime and phosphate on these plots is to be discontinued in order to observe the residual effects. The results of the next few years, therefore, will be awaited with great interest.

For the effect of potassium treatment, Plots 8 and 9 may be compared. No significant response appears as the result of applying potassium, so far as these common field crops show.

A number of problems have arisen out of the experience on this and other experiment fields which call for some revision of the investigations described above, and accordingly certain changes are to be made in the future conduct of these plots which are intended especially to throw more light upon the problems of liming and applying phosphorus. (See Soil Report No. 29, Mercer County Soils.)

Experiments on the Minor Series

The so-called minor system of plots (Series 500, 600, 700, 800) on the Aledo field is given over to a comparison of the effectiveness of different carriers of phosphorus.

In this experiment each series contains four plots. Plot 1 receives residues treatment only; Plot 2 receives residues and phosphorus in one of the forms under test; Plot 3 receives residues, limestone, and phosphorus; and Plot 4 is similar to Plot 3 with phosphorus omitted. On one series steamed bone meal (bP) is used as the carrier of phosphorus and is applied at the rate of 200 pounds per acre per year. On another series acid phosphate (aP) is applied at the yearly rate of 333⅓ pounds per acre. On a third series rock phosphate (rP) serves as the source of phosphorus, applied at the rate of 666⅔ pounds per acre yearly, and on the last series, basic slag phosphate (sP) is applied at the rate of 250 pounds per acre yearly.

The yields for all crops harvested on these plots are recorded in Table 12. Table 13, which is derived from Table 12, shows differences in crop yields presumed to have resulted from applying the various forms of phosphatic fertilizers for the eleven crops harvested since the beginning of the applications up to 1926. In computing these comparisons each phosphate plot is compared with its neighboring non-phosphate plot.

Aside from the soybeans, the figures show without exception more or less crop increase on the phosphorus plots, no matter what the form of carrier employed. The difficulty, however, of arriving at a general conclusion regarding the comparative economy in the use of these different phosphorus materials is obvious, for all depends upon their relative cost, which fluctuates from time to

TABLE 12.—ALEDO FIELD: PHOSPHATE EXPERIMENT
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied[1]	1916[2] Corn	1917[2] Oats	1918[2] Soy-beans	1919 Wheat	1920 Corn	1921 Oats	1922 Clover hay	1923 Corn	1924 Corn	1925 Oats	1926 Wheat
501	R	53.4	85.5	18.9	32.4	72.8	48.9	(2.88)	83.5	58.2	63.9	44.0
502	RbP	61.7	91.7	19.0	34.7	86.4	61.9	(3.25)	82.7	66.0	75.0	59.2
503	RLbP	61.5	90.6	23.2	35.6	87.3	53.3	(3.48)	82.5	66.8	73.4	62.0
504	RL	55.1	80.5	22.6	32.9	77.7	47.7	(2.61)	88.2	60.3	64.5	44.6
601	R	55.2	84.7	19.5	33.0	71.2	53.6	(3.17)	84.7	57.3	64.4	43.3
602	RaP	57.8	87.7	18.7	38.3	87.1	60.9	(3.23)	82.5	65.9	76.1	60.6
603	RLaP	64.7	83.4	23.1	38.2	88.1	52.3	(3.53)	77.6	64.7	78.1	64.4
604	RL	51.9	81.7	24.6	32.8	84.9	50.2	(3.06)	84.1	51.9	64.1	47.3
701	R	54.3	83.1	20.8	34.2	75.6	52.8	(3.41)	82.8	61.2	66.6	44.8
702	RrP	58.8	83.3	23.3	36.7	80.4	63.0	(3.60)	87.8	69.3	70.3	59.2
703	RLrP	57.2	81.2	28.1	36.7	80.2	53.3	(3.82)	86.6	70.8	67.8	57.5
704	RL	52.1	81.7	26.9	34.1	82.0	48.9	(3.15)	84.6	62.5	66.3	49.6
801	R	57.6	73.8	18.0	33.7	68.1	54.8	(2.62)	74.3	58.8	45.0	45.8
802	RsP	56.4	87.8	20.6	38.1	81.0	66.2	(3.66)	80.0	69.1	66.3	60.2
803	RLsP	53.3	78.9	23.7	38.4	83.6	57.0	(3.63)	82.0	70.2	66.7	66.0
804	RL	51.8	77.5	21.8	33.3	70.4	59.8	(2.99)	82.6	59.9	53.9	48.2

[1]Bone meal (bP) at the rate of 200 pounds per acre per year. Acid phosphate (aP) at the rate of 333⅓ pounds per acre per year. Rock phosphate (rP) at the rate of 666⅔ pounds per acre per year. Slag phosphate (sP) at the rate of 250 pounds per acre per year. All minerals applied once in the rotation ahead of the wheat crop.

[2]No residues.

time. Furthermore, the prices received from farm produce likewise fluctuate; and to complicate matters still further, these fluctuations do not necessarily run parallel with those of the fertilizer cost. However, one may readily compute for himself the relative economy of producing these crop increases by applying any set of prices for crops and fertilizers which appear to be most applicable according to prevailing market conditions.

For the purpose of furnishing an illustration of such a computation, the following set of arbitrary prices may be assumed as representing approximately average market conditions for the past ten years: wheat, $1.25 per bushel; corn, 75 cents; oats, 45 cents; soybeans, $1.50; and clover, $15 per ton. For the cost of the various phosphatic materials the following estimates are used: bone meal, $40 per ton; acid phosphate, $24; rock phosphate, $12; and slag phosphate, $20. These values seem to be conservative enough. The figures for crop values represent fairly well the average December 1 farm price quotations for the past decade. Furthermore, it may be pointed out that the quantities of phosphatic materials employed in these experiments are, with the possible exception of the slag phosphate, greater than ordinarily would be used, or need to be used, in good farm practice.

The total value of all the crop increases produced by the various forms of phosphate during the eleven years is shown in Table 13, as is also the total cost of the phosphate applied. From these figures are derived the average annual acre profits shown in the last column of the table.

Reckoned on the basis of the above prices, slag phosphate appears to have furnished the most profitable returns of the four phosphorus carriers in the test, producing an average profit of $5.16 an acre yearly where applied without lime-

TABLE 13.—ALEDO FIELD: AVERAGE ANNUAL CROP INCREASES PRODUCED BY THE VARIOUS FORMS OF PHOSPHATE, AND THEIR VALUE, COMPUTED FROM YIELDS IN TABLE 12

Bushels or (tons) per acre

Comparison of treaments	Wheat *2 crops*	Corn *4 crops*	Oats *3 crops*	Clover *1 crop*	Soy-beans *1 crop*	Value of increase *11 crops*	Cost of phos-phates *11 years*	Profit from *11 crops*	Profit per acre per year
Bone meal, residues, *over* residues	8.8	7.2	10.1	(.37)	.1	$62.93	$44.00	$18.93	$1.72
Bone meal, residues, lime, *over* residues, lime	11.0	4.2	8.2	(.87)	.6	65.12	44.00	21.12	1.92
Acid phosphate, residues, *over* residues	11.3	6.2	7.3	(.06)	− .8	56.41	44.00	12.41	1.13
Acid phosphate, residues, lime, *over* residues, lime	11.3	5.6	6.0	(.47)	−1.5	57.95	44.00	13.95	1.27
Rock phosphate, residues, *over* residues	8.5	5.6	4.7	(.19)	2.5	51.00	44.00	7.00	.64
Rock phosphate, residues, lime, *over* residues, lime	5.7	3.4	1.8	(.67)	1.2	38.73	44.00	−5.27	− .48
Slag phosphate, residues, *over* residues	9.3	6.9	15.4	(1.04)	2.6	84.24	27.50	56.74	5.16
Slag phosphate, residues, lime, *over* residues, lime	11.4	6.1	3.8	(.64)	1.9	64.38	27.50	36.88	3.35

stone, and $3.35 where applied with limestone. Bone meal has given an average profit of $1.72 applied without limestone, and $1.92 applied with limestone. Acid phosphate has returned $1.13 used without limestone, and $1.27 used with limestone. Rock phosphate has produced the lowest money returns, giving a profit of 64 cents an acre a year applied without limestone and a loss of 48 cents used with limestone.

No consideration is given here to the relative phosphorus reserves which should have accumulated in the soil. In considering these figures let it be emphasized again that the order of these values might easily be shifted by a relatively small change in commodity prices.

We may next consider the results from the standpoint of limestone, which was applied at the rate of 4 tons an acre to Plots 3 and 4 of the minor series in 1912, when the land was still under alfalfa. Another dressing of 2 tons an acre was added in 1917, after the present experiments were under way. The effect of this limestone, in terms of crop increase, is set forth in Table 14.

Comparing first the crop yields from Plots 1 and 4, which receive no phosphorus, limestone used with residues alone appears to have been of doubtful benefit to all of the crops excepting soybeans. Considering all treatments as a whole, the soybeans exhibit a consistent gain in yield from the use of limestone, while oats, on the other hand, respond by a consistent loss.

In arriving at the financial results for the use of limestone, a charge of $2 a ton for the 6 tons of limestone applied may be made. This makes a total cost of $12 to charge against the value of the total crop increases for the eleven years. Figured in this manner, we find a profit of 31 cents an acre a year for limestone applied without phosphate of any kind. Where limestone was applied with bone meal, the limestone profit was 5 cents an acre a year, and with acid phosphate

TABLE 14.—ALEDO FIELD: AVERAGE ANNUAL CROP INCREASES PRODUCED BY LIMESTONE AND THEIR VALUE, COMPUTED FROM YIELDS IN TABLE 12

Bushels or (tons) per acre

Comparison of treatments	Wheat *2 crops*	Corn *4 crops*	Oats *3 crops*	Clover *1 crop*	Soy-beans *1 crop*	Value of increase *11 crops*	Cost of phos-phates *11 years*	Profit from *11 crops*	Profit per acre per year
Limestone, residues, *over* residues	1.4	2.0	− .1	−(.07)	4.7	15.36	12.00	3.36	.31
Limestone, residues, bone meal, *over* residues, bone meal	2.8	.3	−3.8	(.23)	4.2	12.52	12.00	.52	.05
Limestone, residues, acid phosphate, *over* residues, acid phosphate	1.9	.5	−3.6	(.30)	4.4	12.49	12.00	.49	.04
Limestone, residues, rock phosphate, *over* residues, rock phosphate	− .9	− .4	−4.8	(.22)	4.8	.57	12.00	−11.43	−1.04
Limestone, residues, slag phosphate, *over* residues, slag phosphate	3.1	.7	− 5.8	− (.03)	3.1	6.22	12.00	− 5.78	− .53

it was 4 cents. Used with rock phosphate, the crop increases were so small that a loss of $1.04 an acre a year was sustained, and with slag phosphate, there was a loss of 53 cents an acre a year.

Considering the small margin of profit and the possible experimental error, it is doubtful whether limestone, used with phosphates in the manner described has, up to the present time, paid its cost on any of these plots. The Aledo field represents one of these borderline cases, so to speak, in which the upper soil is neutral or only slightly acid and the lime requirement, therefore, is not yet very marked. As time goes on, however, and cropping continues, the need of lime may develop. It is planned to discontinue liming on these plots until its need becomes manifest, and in so doing the annual cost of the limestone already applied will become automatically reduced, so that net returns which hitherto have represented a loss may possibly, sooner or later, result in a positive profit.

THE HARTSBURG FIELD

A University soil experiment field representing Black Clay Loam is located in Logan county just east of Hartsburg. This field was established in 1911 and embraces 20 acres. The soil is uniform with the exception of a small area in the northwest part of the field which on the detailed map is identified as of the type Brown Silt Loam On Clay. A thoro system of tile has been installed whereby good drainage has been effected.

The field was laid out into five series of plots, four of which are made up of 10 fifth-acre plots each, and one of which contains 15 fifth-acre plots, as indicated in the diagram (Fig. 3).

The somewhat standard rotation, including alfalfa and the soil treatment methods described on page 39, were established on the five series. Some modifications were made in the order of treatment given the extra five plots on Series 500.

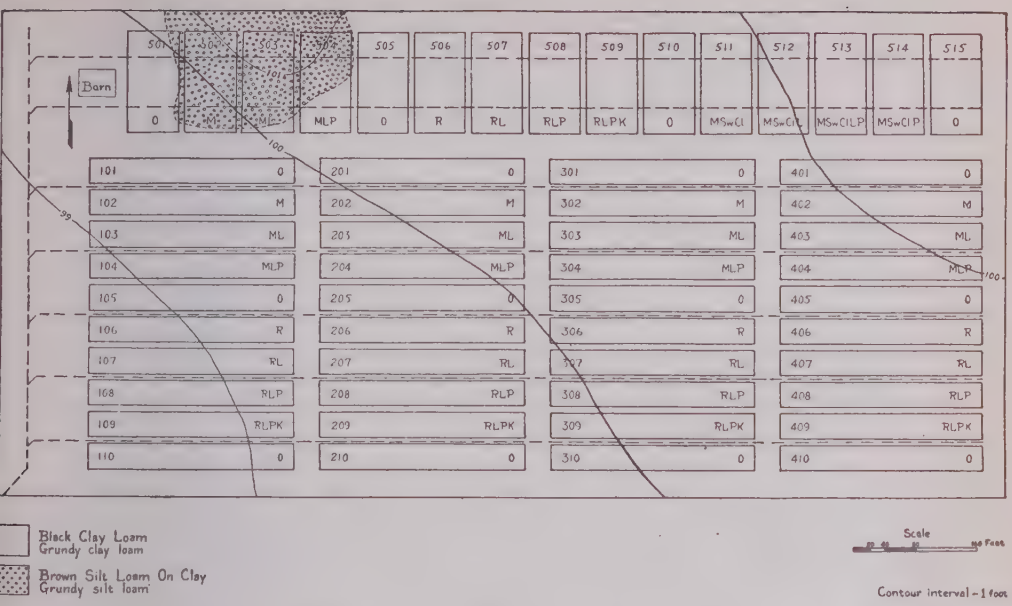


FIG. 3.—DIAGRAM OF THE HARTSBURG SOIL EXPERIMENT FIELD

This diagram shows the arrangement of plots, the soil treatments applied, the location of the different soil types, and by means of contour lines, the natural drainage of this field.

These methods were followed without change until 1918, when it was planned to remove one hay crop and a seed crop of clover from the residues plots. In 1921 it was decided to harvest all the clover as hay. At that time the return of the oat straw was discontinued. In 1922 the return of the wheat straw was discontinued. The only residues plowed under since that time have been the cornstalks, and the green sweet clover before the corn. On this field the sweet clover has grown satisfactorily on the unlimed plots. The application of limestone was also discontinued in 1922 after amounts ranging from 7½ to 10 tons an acre on the different series had been applied, and no more will be added until further need for it becomes apparent. In 1923 the phosphate applications were evened up to 4 tons an acre on all plots, and no more will be applied for an indefinite period. At that time the rotation on Series 100, 200, 300, and 400 was changed to corn, corn, oats, and wheat, with a seeding of hubam clover in the oats on all plots, and a seeding of biennial sweet clover in the wheat on the residues plots. On Series 500 the rotation was changed to corn, oats, wheat, and a mixture of alfalfa and red clover for one year.

Since the Hartsburg field is located in Logan county, a rather complete account of the investigations, including a description of the field and a detailed record of crop yields, is included in this Report. The results of the work described above are given in detail in Table 15, but for convenience in studying them, Table 16 is presented, which gives the average annual yields for the several kinds of crops, including the years since the complete soil treatments have been in effect.

TABLE 15.—HARTSBURG FIELD: ANNUAL CROP YIELDS

Bushels or (tons) per acre

Plot No.	Soil treatment applied	1912 Oats[1]	1913 Clover[2]	1914 Wheat[3]	1915 Corn	1916 Oats	1917 Clover	1918 Wheat	1919 Alfalfa	1920 Alfalfa	1921 Alfalfa	1922 Alfalfa	1923 Corn	1924 Oats	1924 Stubble clover	1925 Wheat	1926 Corn
101	0	39.5	(1.88)	35.9	52.9	62.7	(1.90)	34.0	(1.54)	(3.14)	(3.54)	(4.77)	62.2	80.0	(.83)	33.5	55.2
102	M	30.5	(1.84)	27.9	51.2	59.4	(2.57)	37.3	(1.54)	(2.78)	(3.24)	(4.56)	76.4	85.9	(1.15)	33.3	66.6
103	ML	43.9	(2.03)	36.1	61.9	74.5	(2.51)	39.5	(1.85)	(3.09)	(3.44)	(5.08)	72.0	79.1	(.91)	29.2	68.8
104	MLP	37.2	(1.90)	33.8	64.1	71.2	(2.63)	44.2	(1.90)	(3.82)	(4.19)	(5.37)	76.3	85.3	(1.17)	33.5	74.4
105	0	35.0	2.67	30.2	45.0	53.3	1.75	38.2	(1.82)	(2.44)	(3.21)	(4.63)	72.6	71.3	(.71)	24.8	50.4
106	R	33.0	2.33	30.8	52.1	54.8	2.25	37.3	(1.09)	(3.02)	(3.89)	(5.13)	70.2	71.9	(.75)	31.7	63.6
107	RL	35.3	2.67	32.1	60.5	58.3	2.00	34.1	(1.98)	(3.09)	(3.18)	(5.09)	73.3	64.7	(.68)	23.3	61.6
108	RLP	37.8	2.50	36.0	63.9	60.6	2.50	42.5	(2.92)	(4.17)	(4.17)	(5.59)	72.3	78.8	(.72)	30.5	64.6
109	RLPK	33.0	2.25	36.2	62.7	63.0	2.50	40.5	(2.57)	(4.31)	(4.38)	(5.12)	69.8	78.8	(.80)	33.2	59.2
110	0	31.2	(1.95)	33.7	49.3	56.2	(1.86)	31.4	(1.44)	(2.71)	(3.11)	(4.70)	68.9	78.4	(.75)	30.3	55.4
		Corn[1]	Oats[3]	Soy-beans[3]	Wheat[3]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Corn	Corn		Oats	Wheat
201	0	32.1	25.5	(1.51)	39.9	32.2	45.6	(3.92)	25.9	48.1	34.8	(2.26)	60.6	53.8		36.3	25.8
202	M	33.4	21.9	(1.90)	41.5	36.0	52.2	(4.03)	24.2	58.3	21.9	(2.52)	69.4	62.4		44.4	27.5
203	ML	45.3	25.6	(1.88)	42.8	45.1	61.1	(4.30)	26.5	63.0	32.7	(2.61)	68.1	72.0		44.1	28.2
204	MLP	38.4	24.1	(1.80)	45.1	41.9	56.6	(4.42)	25.2	61.7	33.0	(2.74)	68.3	62.6		44.4	28.0
205	0	35.0	22.8	22.1	40.7	30.7	42.8	.08	27.4	55.2	30.9	(2.51)	72.6	61.2		42.8	27.0
206	R	36.6	20.5	22.6	40.9	48.2	86.9	1.67	23.2	65.2	30.2	(1.93)	72.5	61.8		44.1	28.8
207	RL	37.0	19.5	21.2	34.3	49.9	78.4	2.17	24.2	67.9	34.2	(1.63)	73.5	60.6		41.3	26.8
208	RLP	40.5	22.3	21.2	39.7	45.2	89.4	1.92	25.8	64.3	36.9	(1.88)	72.5	68.4		42.2	34.0
209	RLPK	38.3	24.8	20.8	41.7	44.2	90.3	2.25	23.8	59.0	39.4	(1.60)	72.1	68.0		42.5	32.8
210	0	39.2	22.3	(1.40)	37.8	31.6	43.1	(3.80)	27.2	47.9	31.6	(2.55)	60.6	55.0		40.6	25.8
		Wheat[2]	Corn	Oats	Soy-beans	Wheat	Corn	Oats	Clover	Wheat	Stubble clover	Corn	Oats	Wheat	Corn		Corn	Oats
301	0	.....	21.1	25.8	(1.43)	14.4	38.2	33.1	(.69)	19.8	.....	48.2	37.0	24.8	40.0		44.0	34.7
302	M	.....	21.3	30.9	(1.84)	21.8	48.7	39.8	(.96)	22.0	.....	68.0	47.7	39.3	60.0		65.0	46.3
303	ML	.....	33.1	36.9	(1.96)	29.0	60.7	53.3	(1.13)	43.1	.....	67.3	52.5	42.7	64.0		77.2	49.7
304	MLP	.....	30.0	36.9	(2.23)	34.6	63.7	54.1	(1.16)	44.7	.....	69.0	52.3	42.5	57.4		71.4	43.4
305	0	.....	27.1	33.1	30.8	28.7	43.9	36.6	(.56) .45	36.5	.....	50.1	39.4	32.9	49.0		59.6	43.1
306	R	.....	34.2	31.2	28.4	31.5	79.1	63.1	(.59) .48	37.8	(.42)	60.8	45 8	35.0	68.8		68.6	43.1
307	RL	.....	49.5	32.5	30.1	32.7	84.8	58.6	(.43) .37	34.4	(.68)	63.3	45.9	32.3	73.6		71.4	41.6
308	RLP	.....	41.7	36.4	28.2	34.9	85.7	65.3	(.45) .38	38.2	(.75)	63.1	41.4	34.0	68.0		74.8	42.2
309	RLPK	.....	39.5	35.5	28.9	34.5	84.1	59.4	(.38) .28	37.7	(.65)	63.1	44.7	34.0	76.2		73.8	38.4
310	0	.....	26.7	34.5	(2.00)	26.8	49.1	41.9	(.72)	32.2	.....	58.3	39.7	30.5	48.8		55.2	36.9

[1]Lime only. [2]Yields not taken. [3]No manure.

TABLE 15.—*Concluded*

Bushels or (tons) per acre

Plot No.	Soil treatment applied	1912 Soybeans[1]	1913 Wheat[2]	1914 Corn	1915 Oats	1916 Clover	1917 Wheat	1918 Corn	1919 Oats	1920 Soybeans	1921 Wheat	1922 Corn	1923 Oats	1924 Wheat	1925 Corn	1926 Corn
401	0	12.1	26.2	31.3	48.8	(1.40)	19.1	53.2	33.6	(1.15)	19.3	36.2	43.8	17.5	43.8	35.4
402	M	(.99)	24.8	35.0	58.0	(2.07)	31.7	64.0	41.4	(1.45)	22.8	50.1	62.2	26.2	58.0	54.0
403	ML	(1.12)	29.9	46.5	63.1	(2.12)	32.7	70.7	45.5	(1.68)	30.8	58.7	65.8	40.7	66.2	57.2
404	MLP	(1.20)	33.2	39.0	66.2	(2.28)	42.2	71.4	42.8	(1.62)	38.3	57.9	63.1	37.7	65.0	54.2
405	0	15.0	28.7	33.9	46.9	.67	35.8	62.3	36.6	20.8	24.3	40.7	43.8	21.8	50.0	48.8
406	R	17.5	30.6	41.2	51.6	.50	40.3	70.3	42.7	25.1	33.6	41.5	63.6	29.5	79.6	56.8
407	RL	17.3	28.8	43.0	54.2	.75	34.8	71.8	39.2	26.8	31.3	50.3	48.6	36.2	87.8	63.4
408	RLP	17.4	32.1	45.1	53.3	.83	40.8	67.7	40.0	24.1	36.4	48.2	54.7	36.5	88.4	58.0
409	RLPK	17.6	30.9	45.6	52.0	.67	39.7	61.9	37.5	24.0	33.0	51.3	54.4	34.7	82.8	55.0
410	0	16.1	32.4	38.1	50.2	(2.17)	40.7	65.4	40.0	(1.38)	32.4	44.3	48.8	32.2	49.2	47.2
		Alfalfa[3] seeding	Alfalfa[3]	Alfalfa[3]	Alfalfa[3]	Alfalfa[3]	Alfalfa[3]	Alfalfa[3]	Corn[2]	Oats	Clover	Wheat	Corn	Oats	Wheat	Clover-alfalfa
501	0	.....	(2.36)	(4.11)	(4.67)	(3.17)	(3.20)	(4.22)	69.9	68.4	(2.12)	40.0	58.0	69.1	33.0	(.61)
502	M	.....	(2.89)	(4.23)	(5.20)	(3.66)	(3.84)	(4.76)	72.1	70.0	(2.25)	38.5	66.3	75.8	33.9	(.73)
503	ML	.....	(3.20)	(4.51)	(5.35)	(3.85)	(3.65)	(5.11)	74.5	70.8	(2.45)	39.5	68.5	83.4	38.3	(1.10)
504	MLP	.....	(3.31)	(4.66)	(5.58)	(3.94)	(4.05)	(5.05)	75.8	73.3	(2.39)	41.3	70.1	82.5	34.8	(1.12)
505	0	.....	(1.80)	(3.53)	(4.53)	(3.38)	(3.42)	(4.57)	76.5	57.2	(2.12)	40.7	64.5	65.9	28.3	(.80)
506	R	.....	(2.79)	(4.24)	(5.17)	(3.67)	(3.38)	(4.41)	75.6	58.6	(2.84)	40.9	74.3	69.4	34.1	(1.03)
507	RL	.....	(2.12)	(3.56)	(4.72)	(3.25)	(3.24)	(4.24)	82.4	62.8	(2.18)	35.2	71.3	70.9	26.2	(1.25)
508	RLP	.....	(2.28)	(4.04)	(5.33)	(3.15)	(3.98)	(4.76)	75.5	68.0	(2.37)	39.6	74.6	79.4	29.6	(1.44)
509	RLPK	.....	(2.72)	(4.49)	(5.52)	(3.49)	(4.00)	(4.98)	78.8	63.0	(2.18)	40.5	74.3	77.2	30.4	(1.38)
510	0	.....	(1.87)	(3.71)	(4.46)	(2.60)	(3.14)	(4.24)	65.1	62.2	(2.27)	37.3	63.8	60.9	26.1	(.78)
511	RM	.....	(2.45)	(3.61)	(4.52)	(2.79)	(2.83)	(4.05)	74.2	72.0	(2.22)	37.8	72.4	70.8	30.4	(.82)
512	RML	.....	(2.79)	(3.76)	(4.61)	(2.94)	(2.92)	(4.14)	74.3	73.8	(2.15)	36.8	74.7	78.8	30.5	(.99)
513	RMLP	.....	(3.71)	(4.63)	(5.03)	(3.36)	(3.45)	(4.57)	68.7	76.7	(2.38)	40.8	66.3	83.9	33.7	(.96)
514	RMP	.....	(3.30)	(4.73)	(5.09)	(3.96)	(3.87)	(4.70)	68.0	70.6	(2.67)	41.4	68.2	76.4	29.7	(.00)
515	0	.....	(1.79)	(3.92)	(4.19)	(2.81)	(2.39)	(3.20)	59.3	52.2	(1.84)	35.3	51.7	60.2	22.9	(.00)

[1]Lime only. [2]No manure. [3]No residues.

TABLE 16.—HARTSBURG FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1913-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *12 crops*	Corn *19 crops*	Oats *14 crops*	Clover *7 crops*	Soybeans *2 crops*	Alfalfa[1] *11 crops*
1	0	25.6	46.5	46.7	(1.84)	(1.29)	(3.47)
2	M	29.9	57.0	52.6	(2.19)	(1.64)	(3.67)
3	ML	35.0	62.9	58.0	(2.32)	(1.82)	(3.91)
4	MLP	37.2	61.8	57.5	(2.39)	(1.92)	(4.19)
5	0	30.5	52.1	46.0	(1.28)	25.8	(3.33)
6	R	33.6	62.3	54.1	(1.67)	26.8	(3.78)
7	RL	31.0	66.3	52.2	(1.64)	28.4	(3.45)
8	RLP	35.2	65.4	56.3	(1.79)	26.1	(4.04)
9	RLPK	34.6	64.3	55.4	(2.13)	26.4	(4.16)
10	0	31.1	51.6	47.4	(2.02)	(1.69)	(3.20)
	Crop Increases						
	M over 0	4.3	10.5	5.9	(.35)	(.35)	(.20)
	R over 0	3.1	10.2	8.1	(.39)	1.0	(.45)
	ML over M	5.1	5.9	5.4	(.13)	(.18)	(.24)
	RL over R	−2.6	4.0	−1.9	−(.03)	1.6	−(.33)
	MLP over ML	2.2	−1.1	− .5	(.07)	(.10)	(.28)
	RLP over RL	4.2	− .9	4.1	(.15)	−2.3	(.59)
	RLPK over RLP	− .6	−1.1	− .9	(.34)	.3	(.12)

[1]No residues for the first six crops.

The outstanding feature of the results of the Hartsburg field is the large increase in yields produced by organic manures, whether they be in form of crop residues or of stable manure.

The behavior of limestone on this field presents a peculiarity difficult to explain in that limestone has been much more beneficial where applied with animal manure than where used with residues. Used with manure, limestone shows a marked increase in all crops and has given profitable returns on the investment, while in the residues system the effect of this material on several of the crops appears as negative and its use in this system has been attended by a financial loss.

Rock phosphate has found its most effective place in these experiments in the production of wheat and of alfalfa, particularly in the residues system, but its effect on the other crops has been so indifferent that, on the whole, the use of this material has not proved profitable on this field.

The addition of potassium in the combinations here employed has likewise been ineffective.

In 1924 these plots were divided into west and east halves and some new treatments designed to furnish further information regarding the effect of phosphorus fertilizers on this soil were introduced on the east halves. The west halves were continued under the old treatments except that the phosphate applications were discontinued indefinitely after a total of four tons an acre of rock phosphate had been applied. The phosphate applications were likewise suspended on the east half of Plot 9 on all series.

TABLE 17.—HARTSBURG FIELD: SPECIAL PHOSPHATE EXPERIMENTS
Annual Crop Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment	1924					1925				1926			
		Series 100 Oats	Series 100 Stubble clover	Series 200 Corn	Series 300 Corn	Series 400 Wheat	Series 100 Wheat	Series 200 Oats	Series 300 Corn	Series 400 Corn	Series 100 Corn	Series 200 Wheat	Series 300 Oats	Series 400 Corn
						West Half-Plots								
1	0	80.0	(.83)	53.8	40.0	17.5	33.5	36.3	44.0	43.8	55.2	25.8	34.7	35.4
2	M	85.9	(1.15)	62.4	60.0	26.2	33.3	44.4	65.0	58.0	66.6	27.5	46.3	54.0
3	ML	79.1	(.91)	72.0	64.0	40.7	29.2	44.1	77.2	66.2	68.8	28.2	49.7	57.2
4	MLrP	85.3	(1.17)	62.6	57.4	37.7	33.5	44.4	71.4	65.0	74.4	28.0	43.4	54.2
5	0	71.3	(.71)	61.2	49.0	21.8	24.8	42.8	59.6	50.0	50.4	27.0	43.1	44.8
6	R	71.9	(.75)	61.8	68.8	29.5	31.7	44.1	68.6	79.6	63.6	28.8	43.1	56.8
7	RL	64.7	(.68)	60.6	73.6	36.2	23.3	41.3	71.4	87.8	61.6	26.8	41.6	63.4
8	RLrP	78.8	(.72)	68.4	68.0	36.5	30.5	42.2	74.8	88.4	64.6	34.0	42.2	58.0
9	RLrPK	78.8	(.80)	68.0	76.2	34.7	33.2	42.5	73.8	82.8	59.2	32.8	38.4	55.0
10	0	78.4	(.75)	55.0	48.8	32.2	30.3	40.6	55.2	49.2	55.4	25.8	36.9	47.2
						East Half-Plots								
1	RL	74.4	(.75)	51.8	40.4	15.8	28.2	41.6	44.6	51.8	63.6	27.7	30.3	35.6
2	MrP	85.3	(1.12)	67.6	56.4	26.8	33.3	46.6	71.8	58.6	72.0	33.7	46.9	52.6
3	MLbP	77.5	(.89)	63.8	64.4	39.3	31.2	49.4	71.4	68.6	69.6	30.0	43.8	54.6
4	MLrP	84.1	(1.38)	67.8	61.6	39.0	36.0	48.4	71.4	64.8	69.2	32.3	45.9	58.8
5	RaP	78.1	(.74)	60.8	44.4	29.8	33.7	49.1	64.4	78.2	71.4	30.2	35.0	37.8
6	RrP	73.8	(.74)	66.8	67.2	45.5	38.7	49.7	69.8	80.2	72.2	34.8	41.3	58.0
7	RLaP	63.8	(.79)	56.8	72.6	39.5	39.8	49.7	81.2	75.4	70.2	34.5	43.8	61.2
8	RLrP	79.8	(.72)	68.0	73.6	43.3	31.5	46.3	70.4	73.0	65.6	33.3	44.4	61.6
9	RLrPK—Gypsum	82.8	(.83)	70.0	76.0	39.8	30.8	45.9	75.8	70.4	56.2	33.5	40.9	63.8
10	RLrP	75.9	(.69)	58.2	46.8	34.3	33.2	42.5	73.6	70.6	65.4	28.3	35.3	47.2

In the new treatments bone meal, acid phosphate, and rock phosphate are being compared in different combinations, as indicated in Table 17. These phosphate fertilizers are applied twice in the rotation, one-half in preparation for the wheat crop and one-half ahead of the first corn crop at the following annual acre-rates: rock phosphate, 500 pounds; acid phosphate, 200 pounds; bone meal, 200 pounds. Gypsum also is being added to Plot 9 at the rate of 200 pounds. Two tons an acre of limestone were given Plots 1–East and 10–East on all series in 1924, more to be added in amounts necessary to maintain good growing conditions for the legumes.

Altho these new experiments have not been under way long enough to warrant an analysis of the results at this time, the yields for the three years are all presented in Table 17 as a matter of record.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1926
33 Saline, 1926
34 Marion, 1926
35 Will, 1926
36 Woodford, 1927
37 Lee, 1927
38 Ogle, 1927
39 Logan, 1927

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UNIVERSITY OF ILLINOIS
Agricultural Experiment Station

SOIL REPORT NO. 40

WHITESIDE COUNTY SOILS

BY R. S. SMITH, O. I. ELLIS, E. E. DeTURK, F. C. BAUER,
AND L. H. SMITH

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URBANA, ILLINOIS, JUNE, 1928

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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[1] Deceased.
[2] Engaged in Soils Extension as well as in Soil Experiment Fields.
[3] On leave.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Whiteside county was conducted.

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WHITESIDE COUNTY SOILS

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WHITESIDE COUNTY SOILS

By R. S. SMITH, O. I. ELLIS, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

Whiteside county is situated on the Mississippi river in the northwestern part of Illinois about 40 miles south of the Wisconsin state line. It has an area of about 700 square miles.

The climate of Whiteside county is characterized by a wide range in temperature between the extremes of winter and summer. Records from the weather station at Morrison, Illinois, show that the greatest range in temperature for any one year during the past twenty-three years was 130 degrees in 1914. The highest temperature recorded during this period was 107°; the lowest, 30° below zero. The average date of the last killing frost in the spring is May 4. The latest killing frost recorded was May 27 in 1907. The average date of the first killing frost in the fall is October 12, and September 11 is the earliest date on which such a frost has occurred. The average length of the growing season is 161 days.

The average annual rainfall during this period of twenty-three years was 33.92 inches, distributed as follows: January, 1.47 inches; February, 1.55; March, 2.58; April 3.10; May, 4.22; June, 4.03; July, 3.46; August, 3.75; September, 4.00; October, 2.36; November, 1.81; December, 1.54.

The topography of Whiteside county varies from flat to rough and broken. The southern and southwestern portions of the county are flat except where broken by sand dunes or dune-like topography, resulting from wind action. In the northern and northwestern parts of the county rough, broken land occurs. This broken topography is the result of stream erosion.

The drainage of the county all finds its way into Mississippi river, for the most part thru Rock river. The swamp and terrace areas south of Rock river and in the neighborhood of the village of Erie, north of Rock river, are underlain by sand and gravel. Because of the high water table, however, the drainage of these areas was not good until dredge ditches were constructed. Meredosia slough, which forms the boundary between Rock Island and Whiteside counties, is a sluggish stream. It serves as a cut-off between Mississippi and Rock rivers during periods of high water.

The altitudes at a few points in Whiteside county are as follows: Sterling, 649 feet; Morrison, 670; Fulton, 594; Albany, 586; Erie, 597; Prophetstown, 627; Tampico, 647.

AGRICULTURAL PRODUCTION

A diversity of interests is represented in the agriculture of Whiteside county, the more important of which are grain production, livestock, and dairying. On some farms one or another of these enterprises predominates, while on other

[1] R. S. Smith, in charge of soil survey mapping; O. I. Ellis, Assistant Chief in soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

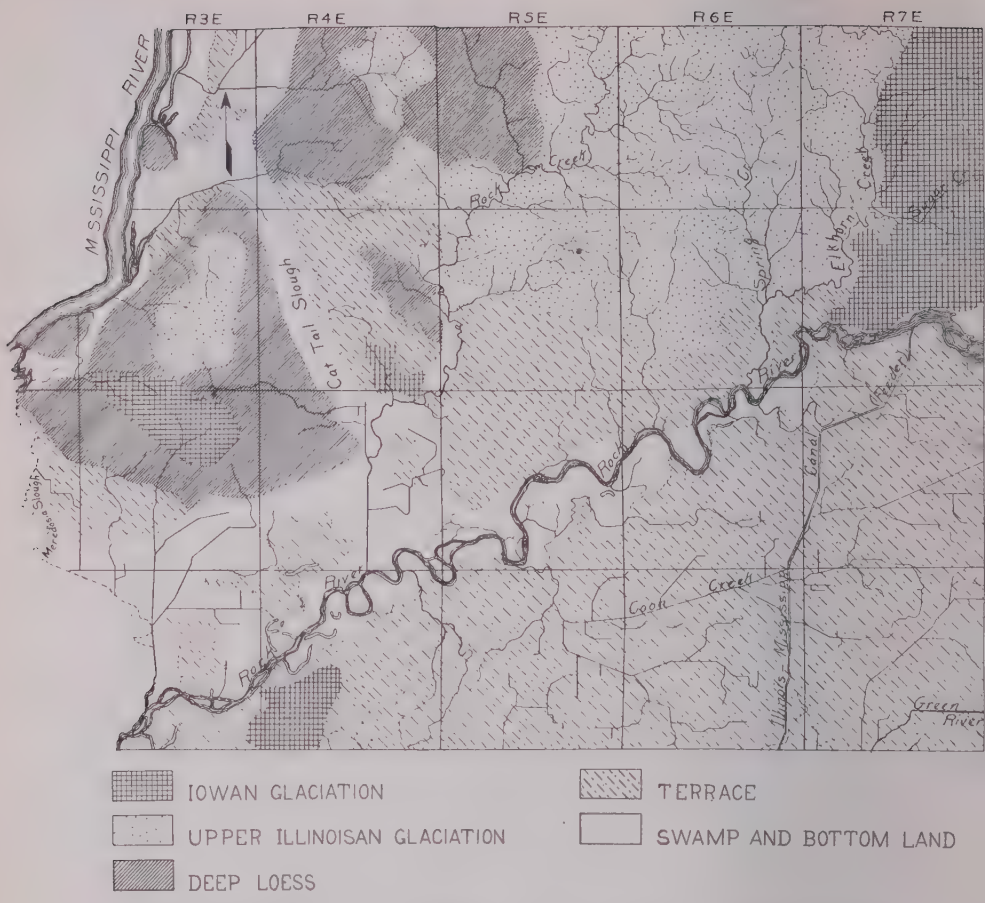


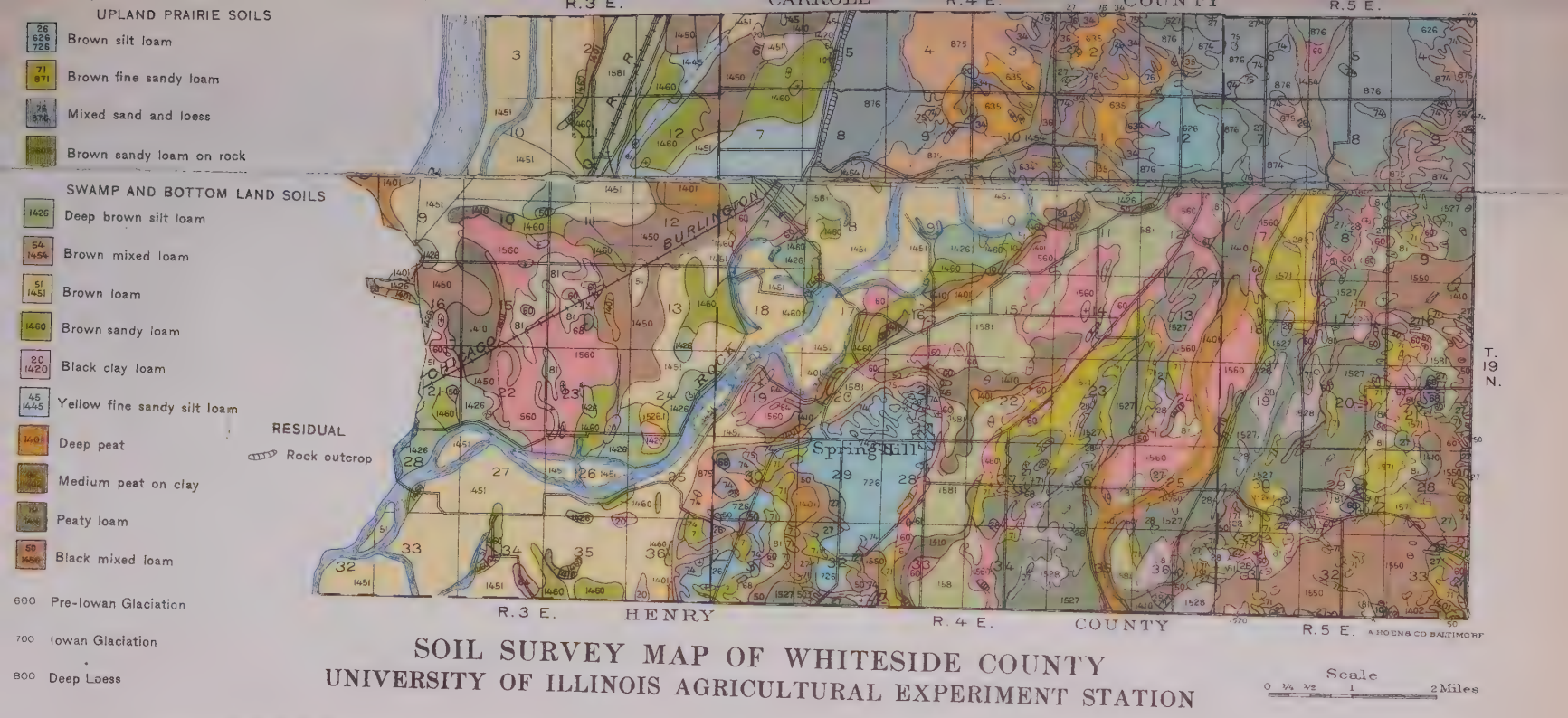
FIG. 1.—DRAINAGE MAP OF WHITESIDE COUNTY, SHOWING STREAM COURSES AND GEOLOGICAL AREAS

farms a combination of them is found. Taking the county as a whole, the most important sources of farm income are dairy products, beef cattle, and hogs, supplemented by the sale of grains and hay.

The livestock industry is well developed on the uplands in the western part of the county where the land is adapted to pasture because of its rough and broken topography. The dairy industry is centered around Morrison, Sterling, and Rock Falls. Most of the milk is hauled in by trucks to the condensories which are located in these towns.

The lowlands in the terrace and swamp area south of Rock river have, for many years, been in pasture because of the lack of proper drainage. Within recent years these lowlands for the most part have been sufficiently drained by dredges and tile to permit cultivation.

Sweet clover, alfalfa, and red clover grow very well on many of the soil types in the county without liming. A mixture of vetch and rye is grown on



SOIL SURVEY MAP OF WHITESIDE COUNTY

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much of the sandy soil. A rough estimate places the area devoted to pasture at 55,000 to 60,000 acres. A very large proportion of this pasture land is too rough for cultivation.

As a rule, each farm includes a small truck garden and orchard. In the deep loess region in the western part of the county, some commercial orcharding is carried on.

According to the Fourteenth Census of the United States there were 2,789 farms in Whiteside county in 1920, a decrease of 109 farms in ten years.

The following table shows the acreage and yield of the more important crops for the year 1919, as given by the above-mentioned Census.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	110,537	4,796,574 bu.	43.4 bu.
Oats	57,632	1,869,165 bu.	32.4 bu.
Wheat	26,397	615,726 bu.	23.3 bu.
Rye	20,946	291,213 bu.	13.9 bu.
Barley	8,864	199,270 bu.	22.4 bu.
Timothy	8,946	12,460 tons	1.39 tons
Timothy and clover mixed	22,782	36,089 tons	1.58 tons
Clover	4,437	7,565 tons	1.70 tons
Alfalfa	588	1,610 tons	2.74 tons
Silage crops	7,700	70,044 tons	9.09 tons
Corn for forage	8,218	20,202 tons	2.45 tons

It should be borne in mind that these figures represent the yields for only a single season. Figures furnished by the U. S. Department of Agriculture give the following average acre-yields for the five-year period, 1921-1925: corn, 41.4 bushels; oats, 37.1 bushels; wheat, 20.1 bushels; tame hay, 1.46 tons.

The following figures taken from the 1920 Census show the character of the livestock interests in Whiteside county. The total value of livestock was $7,919,000 in 1919.

Animals and Animal Products	*Number*	*Value*
Horses	19,213	$1,582,149
Mules	590	64,989
Beef cattle	25,455	1,731,900
Dairy cattle	35,993	2,497,977
Swine	85,927	1,961,405
Sheep	6,107	80,005
Value of eggs and chickens	.....	828,923
Value of dairy products	.....	1,804,767

ORIGIN AND DEVELOPMENT OF SOILS

One of the most important periods in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during and immediately following which there was being deposited the material that later formed the mineral portion of the soils. From the centers of accumulation in Labrador, in the Hudson Bay region, and in the northern Rocky mountains, at least six great ice sheets moved southward, each of which covered a part of northern United States, altho the same parts were not covered during each advance.

Whiteside county occupies a region which has been subjected to vigorous glacial and stream action. The exact glacial history of the region is not fully known, but for the purpose of the soil survey, it is sufficient to note that the

glacial, stream, and wind action was such as to cover the entire county with loess to a depth varying from about 150 feet in the western portion to 15 or 20 feet in the eastern portion. A few restricted areas in the eastern portion of the county have a loess cover of only about 5 feet, but loess is the material from which nearly all the soils of the county, as we find them today, were formed. Sand dunes occur, chiefly along Mississippi river and Meredosia slough and south of Rock river. This sand material was segregated by the wind from the alluvial material deposited by the streams. It now forms undesirable soil because of its coarse texture and relative poverty in the elements of plant food. A number of peat deposits occur in Whiteside county. These deposits occur in depressions where excess water favored the growth of swamp vegetation and the accumulation of deep deposits of this organic material.

Limestone outcrops occur in the northwestern part of the county, but they are not extensive. The reader is referred to State Geological Survey Bulletin No. 46 for information regarding the quantity, quality, and availability of the limestone outcrops in Whiteside county.

Immediately following the deposit of the soil material, the forces of weathering began the development of the soils as they now occur. The upland became, for the most part, covered by a grass vegetation, thus very largely preventing erosion and making possible the slow but uninterrupted accumulation of organic matter and the formation of the dark-colored prairie soils. The upland adjacent to the streams is occupied by light-colored soil, due to the fact that trees invaded the land along the streams, thus bringing about conditions unfavorable for the accumulation of organic matter. During this time the movement of water thru the soil caused the formation of layers or horizons, commonly spoken of as surface or A_1 horizon, subsurface or A_2 horizon, and subsoil or B horizon. The less-weathered material below the B horizon is spoken of as the C horizon, and its character, particularly with reference to presence or absence of limestone particles, is important.

The bottom lands are occupied by alluvial, or water-borne, material which, because of its recent deposition and continued movement by the wind, has not formed distinct horizons.

SOIL GROUPS

The soils of Whiteside county are divided into the following groups:

Upland Prairie Soils, including the dark-colored upland soils.

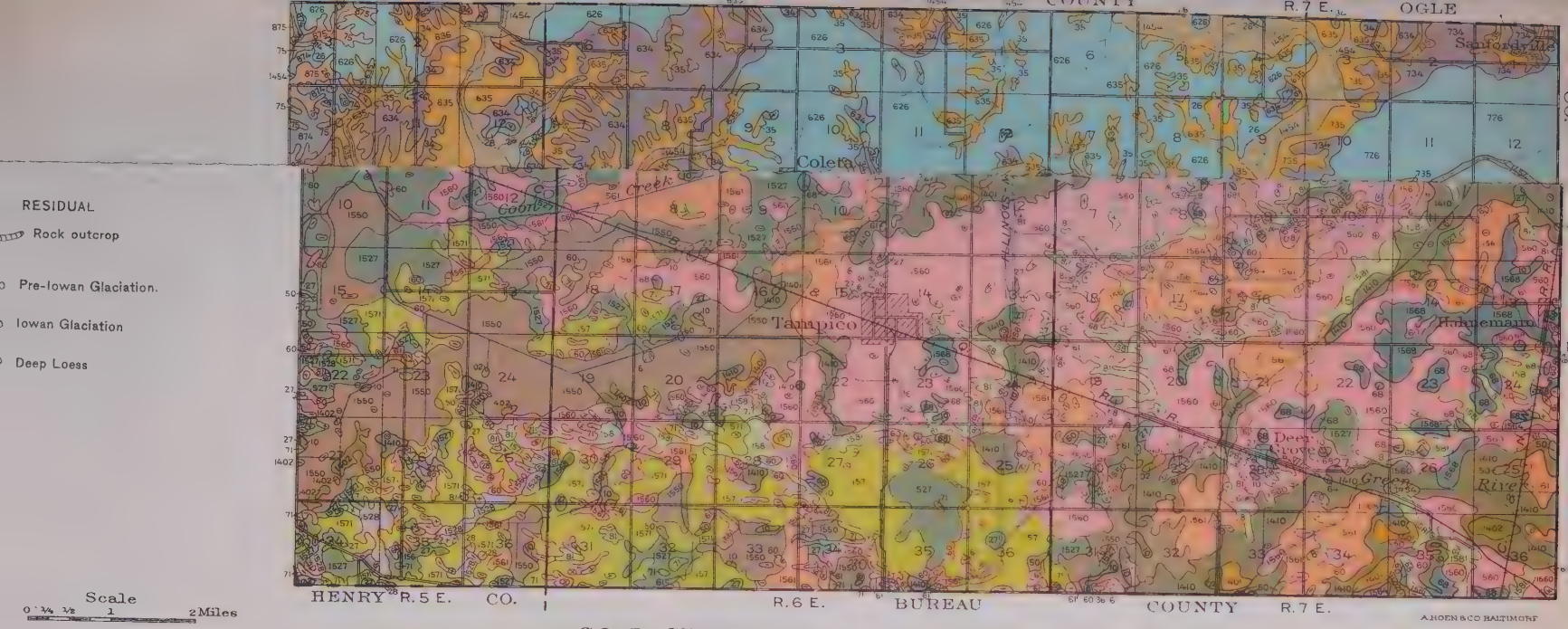
Upland Timber Soils, including the light-colored upland soils.

Terrace Soils, including alluvial soils now above overflow or rarely under water.

Swamp and Bottom-Land Soils, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

Residual Soils, including rock outcrop areas and soils formed in place thru weathering of rocks.

Table 1 gives the list of soil types found in Whiteside county, the area of each in square miles and in acres, and also its percentage of the total area. The



SOIL SURVEY MAP OF WHITESIDE COUNTY

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accompanying map in two sheets shows the location and boundary of each type down to areas a few acres in extent. For explanations concerning the classification of soils and interpretation of the map, the reader is referred to the first part of the Appendix to this report.

TABLE 1.—SOIL TYPES OF WHITESIDE COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils (600, 700, 800)			
626 726	Brown Silt Loam	93.28	59,699	13.31
871	Brown Fine Sandy Loam	9.99	6,394	1.43
876	Mixed Sand and Loess	25.91	16,582	3.70
660.5	Brown Sandy Loam On Rock	.29	186	.04
		129.47	82,861	18.48
	Upland Timber Soils (600, 700, 800)			
634 734	Yellow-Gray Silt Loam	26.65	17,056	3.80
635 735	Yellow Silt Loam	38.48	24,627	5.49
874	Yellow-Gray Fine Sandy Loam	27.58	17,651	3.93
875	Yellow Fine Sandy Loam	35.76	22,886	5.10
		128.47	82,220	18.32
	Terrace Soils (1500)			
1527	Brown Silt Loam Over Gravel	73.97	47,341	10.55
1536	Yellow-Gray Silt Loam Over Gravel	3.70	2,368	.53
1526.1	Brown Silt Loam On Clay	1.55	992	.22
1528	Brown-Gray Silt Loam On Tight Clay	4.17	2,669	.59
1571	Brown Fine Sandy Loam	13.56	8,678	1.93
1550	Black Mixed Loam	27.87	17,837	3.98
1561	Black Sandy Loam	22.36	14,310	3.19
1560	Brown Sandy Loam	86.57	55,405	12.35
1568	Brown-Gray Sandy Loam On Tight Clay	4.22	2,701	.60
1564	Yellow-Gray Sandy Loam	.72	461	.10
1581	Dune Sand	33.25	21,280	4.75
1520	Black Clay Loam	.17	109	.03
		272.11	174,151	38.82
	Swamp and Bottom-Land Soils (1400)			
1426	Deep Brown Silt Loam	28.53	18,259	4.07
1454	Brown Mixed Loam	24.07	15,405	3.43
1451	Brown Loam	33.78	21,619	4.82
1460	Brown Sandy Loam	22.99	14,714	3.28
1420	Black Clay Loam	2.41	1,542	.34
1445	Yellow Fine Sandy Silt Loam	6.64	4,250	.95
1401	Deep Peat	14.60	9,344	2.08
1402	Medium Peat On Clay	.91	582	.13
1410	Peaty Loam	19.35	12,384	2.77
1450	Black Mixed Loam	8.28	5,299	1.18
		161.56	103,398	23.05
	Residual Soils (000)			
099	Rock Outcrop	.12	77	.02
	Miscellaneous			
	Water	9.17	5,869	1.31
	Total	700.90	448,576	100.00

INVOICE OF THE ELEMENTS OF PLANT FOOD IN WHITESIDE COUNTY SOILS

THREE DEPTHS REPRESENTED BY SOIL SAMPLES

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum, over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.
2. A middle stratum extending from 6⅔ to 20 inches, and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches, and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling we have represented separately three zones for plant feeding. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore, it is the only stratum which can be greatly changed in composition as a result of adding plant food.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires to consider the information in that form. In comparing the composition of the different strata, it must be kept in mind that it is based on different quantities of soil, as indicated above. In order to show the comparative concentration of the various constituents in the different strata, the figures for the middle and lower strata must, therefore, be divided by two and three respectively.

Wide Range in Organic Matter and Nitrogen

It can readily be seen from Table 2 that there is a wide variation among the different soil types of Whiteside county with respect to their content of the different plant-food elements in the upper 6⅔ inches of soil. There appears to be but little relationship among these variations except with respect to organic carbon and nitrogen, the quantities of which run parallel from type to type tho the organic-carbon content is usually 10 to 12 times as great as the nitrogen. This relationship between organic carbon and nitrogen is explained by the well-established facts that all soil organic matter (of which organic carbon is the measure) contains nitrogen and that most of the soil nitrogen—usually 98 percent or more—is present in a state of organic combination, that is, as a part of the organic matter.

The upland prairie soils of Whiteside county are, for the most part, relatively high in organic matter and nitrogen; the upland timber soils in general fairly low, altho there is some overlapping in the two groups with respect to these constituents. For example, the lowest amount of organic carbon found among the upland prairie types, 20,800 pounds an acre in Brown Sandy Loam On Rock, is somewhat lower than the highest value in the upland timber group,

25,020 pounds in Yellow-Gray Silt Loam, even tho the upland prairie soils as a whole contain more than twice as much organic carbon as the timber soils. Their respective averages are 42,300 and 19,310 pounds for the surface 6⅔ inches.

The terrace and bottom-land soils contain, in general, more organic matter than the upland soils, altho wide variations are to be found also among the different types within each of these two groups.

The largest amount of organic carbon is found in Deep Peat. Since organic matter is approximately half carbon, the 352,360 pounds of organic carbon in a million pounds of this soil correspond to 704,720 pounds of organic matter, or to 70.5 percent of the soil. The lowest amount of this constituent, 11,800 pounds an acre, is found in Yellow-Gray Sandy Loam, Terrace; while Dune Sand, Terrace, with 14,670 pounds, and Yellow Fine Sandy Loam, Upland, with 12,620 pounds, are close seconds. Soils of this character present unusual difficulty when it comes to maintaining an adequate supply of organic matter, their porous, open texture permitting its rapid oxidation, so that it disappears much more rapidly than from the heavier types. For this reason especial care should be taken to provide frequent green-manuring crops as well as any other available organic residues which may be used for maintaining a supply of organic matter. These soils are usually acid, and consequently the application of limestone is in most cases the first step in their improvement.

With the exception of Deep Peat, all the soil types diminish rather rapidly in organic matter and nitrogen with increasing depth, and this diminution is noticeable even in the middle stratum.

Phosphorus Content Increases From Light to Heavy Types

The sandy soils contain, on the whole, less total phosphorus than those of heavier texture. The smallest quantity, 620 pounds in the upper stratum, was found in Yellow-Gray Sandy Loam, Terrace. All the very sandy soils, as well as the light-colored timber soils, are somewhat low in total phosphorus. Such soils, while they generally respond to phosphate fertilization, do not produce the increases for such treatment that might be expected, in part because of the greater feeding range for crop roots afforded by the loose, penetrable character of these types. On the whole, soils which are very high in organic matter are usually somewhat high in total phosphorus. Thus Black Clay Loam, Deep Brown Silt Loam, Deep Peat, and other types carrying 80,000 pounds or more of organic carbon in the surface soil of an acre usually have about 2,000 pounds or more of phosphorus in that stratum.

Phosphorus, unlike some other elements, is not appreciably removed from the soil by leaching. It is converted by growing plants into organic form and tends to accumulate in the surface soil in plant residues at the expense of underlying strata. Investigations at the Illinois Station have shown that in Brown Silt Loam, for example, about 33 percent of the total phosphorus of the surface soil is organic, and in Black Clay Loam about 37 percent. It is the second stratum (6⅔ to 20 inches) which furnishes most of the phosphorus thus moved upward. Consequently in the majority of soil types the surface soil contains a larger proportion of phosphorus than the middle stratum and, in some cases, more than the lower stratum.

Sulfur Generally Well Supplied

While other elements are not so closely associated with each other as are organic matter and nitrogen, there is some degree of correlation between sulfur, another element used by growing plants, and organic carbon. This is because a considerable tho varying proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of organic matter.

Most of the Whiteside county soils are fairly well supplied with sulfur altho some low values are found. It ranges in the surface soil from a minimum of 180 pounds an acre in Brown Sandy Loam On Rock up to 3,340 pounds in Deep Peat. Excluding the peat soils, the sulfur content of Whiteside county soils averages a little less than half that of phosphorus.

The sulfur content decreases with depth in nearly all cases as may be seen from a comparison of the figures in Tables 2, 3, and 4. This is to be expected since, as stated above, a portion of the sulfur exists in combination with the organic matter of the soil and not only is the organic matter more abundant in the upper stratum, but also the organic forms of sulfur are held more tenaciously against the leaching action of ground water than are the inorganic forms.

The sulfur available to crops, however, is affected not only by the soil supply but also by that brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption the amount of sulfur thus added to the soil is relatively large. At Urbana during the eight-year period from 1917 to 1924 there has been added to the soil by the rainfall an average of 3.5 pounds of sulfur an acre a month. Similar observations have been made in other localities for shorter periods. The precipitation at the various points in the state in a single month has varied from a minimum of ¾ of a pound to more than 10 pounds an acre.

These figures afford some idea of the amount of sulfur added by rain, and also of the wide variations under different conditions. On the whole, the facts would indicate that the sulfur added from the atmosphere supplements adequately that contained in the soil, so that apparently there is little need for sulfur fertilizers in Whiteside county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started on a number of the Illinois experiment fields.

Potassium Deficient in Peat and Sand Types

Potassium is deficient both in Deep Peat and in Medium Peat On Clay, as is usually the case with these types; the total amounts in the upper 6⅔ inches are 4,590 and 9,030 pounds an acre respectively. A number of the sandy types in Whiteside county are comparatively low in their content of this element. Black Sandy Loam, Brown-Gray Sandy Loam On Tight Clay, and Dune Sand contain, for example only 19,000 to 21,000 pounds per acre of this element and Peaty Loam only 20,590 pounds. These amounts are about two-thirds as high as the 33,000-pound value around which most of the types vary. This condition, however, does not extend to all the sandy types.

Sandy soils, besides containing generally less total potassium than the heavier types, carry a large proportion of their potassium in the coarse sand grains. The relatively smaller total surface exposed in the case of these coarser soil particles reduces the rate at which potassium is dissolved, thus lowering its availability. This deficiency of available potassium in sandy soils may be offset, partly at least, by the greater facility with which crop roots can penetrate soils of that character as compared with heavier types.

The other soil types of Whiteside county are normal in their content of potassium. Potassium exhibits little difference in concentration in the three sampling layers.

Calcium and Magnesium Vary Widely Within the Type

The variations in the amounts of calcium and magnesium present in the soils of Whiteside county are very wide, tho none of the types are particularly low in either of these elements. In very acid soils it sometimes happens that the calcium present is in such highly insoluble forms that there is not enough of it available for good crop growth. The benefit realized from liming acid soils may, therefore, be due not wholly to the correction of acidity but in part to the fact that the limestone supplies calcium as a plant-food element in a form which rapidly becomes available to crops.

Variations in the amounts of these two elements in the different depths of those soils which do not contain native calcium carbonate furnish a clue as to the translocations of these elements during the long period in which the different types were developing. In the surface stratum calcium exceeds magnesium in most cases. This would indicate a larger percentage of calcium than of magnesium in the soil-forming materials. The idea is also in harmony with geological evidence. With increasing depth we find the calcium concentration about the same as in the surface, while an increase in magnesium occurs in the second stratum and becomes very pronounced in the lower.

This situation may be explained by the fact that as these two elements are dissolved from the surface soil, they are carried downward in solution. In the downward movement magnesium is more readily reabsorbed by the soil mass than calcium, tending to force calcium into the solution to be carried farther down. Consequently, while magnesium tends to accumulate in the middle and lower strata, the liberated calcium may accumulate at still greater depths or may be washed away entirely. These movements of calcium and magnesium, as indicated by the analyses of the different strata, constitute one factor in estimating the relative maturity of the various soil types. The higher proportion of magnesium to calcium in the lower levels as compared to the surface soil tends, in general, to increase with the more fully developed or mature profiles. Thus we see a correlation of this chemical characteristic of the soil with the processes of its development.

Some of the calcium figures, as given in the tables, appear to be very erratic. The very large amounts of calcium in some of the types are an indication of the presence of finely divided native calcium carbonate (limestone) in some or all of the samples of such types. Sometimes calcium carbonate is present in the surface stratum, as in the case of Black Sandy Loam, with its high calcium figure of

53,620 pounds an acre. Again, being fairly soluble in the soil water, the calcium carbonate has leached away from the upper stratum in some soils, but is still present in the middle or in the lower stratum. Brown Sandy Loam, Bottom, illustrates this condition. In this type the upper and middle strata are acid in all samples collected and the calcium content is, on the whole, no higher than in other types, namely, 10,970 pounds per acre in the upper and 34,460 pounds in the second stratum. The lower stratum, however, has 217,470 pounds of calcium in 6 million pounds of soil, which after being converted to the 2-million pound basis for comparison with the surface stratum is found to be nearly seven times as concentrated. The lower stratum in this case contains a large amount of calcium carbonate which has not yet been leached away, and this is responsible for the high figure for total calcium.

Some increase in total magnesium will be observed accompanying the high calcium of the carbonate-containing soils. These are not great, however, since the magnesium does not readily persist in the soil as the carbonate. The carbonate of carbonate-containing soils is chiefly that of calcium.

Local Tests for Soil Acidity Often Required

It is impracticable to attempt to obtain an average quantitative measure of the calcium carbonate present in a given type because, while some samples contain large amounts, others contain none, but on the other hand have a lime requirement due to the soil acidity. We thus have what may be considered positive and negative values ranging, perhaps widely, on the opposite sides of the zero or neutral point, the numerical average of which could have no significance whatever, since it would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types.

The qualitative field tests made in the process of the soil survey are much more numerous than the chemical analyses made in the laboratory, and do give a general idea of the predominating condition in the various types as to acidity or alkalinity. These tests, therefore, furnish the basis for some general recommendations which are given in the descriptions of individual types on pages 14 to 29. To have a sound basis for the application of limestone the owner or operator of a farm must often determine individually the lime-requirements of his different fields. The section in the Appendix dealing with the application of limestone (page 37) is pertinent and should be read in this connection.

Supplies of Different Elements Not Proportional to Crop Removal

In the foregoing discussion we have considered mainly the amounts of the plant-food elements in the surface 6⅔ inches of soil, and rather briefly the relative amounts in the two lower strata. We have noted that some of the elements of plant food exhibit no consistent change in amount with increasing depth. Other elements show more or less marked variation at the different levels, the trend of these variations serving in some cases as clues to the relative maturity of different types and the processes involved in their development.

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF WHITESIDE COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils, (600, 700, 800)							
626, 726	Brown Silt Loam	61 150	4 850	1 200	670	34 120	8 270	11 710
871	Brown Fine Sandy Loam	44 940	3 930	1 220	740	32 570	7 700	11 640
876	Mixed Sand and Loess[1]	.....	.....	.....	.....	.....	.....	.....
660.5	Brown Sandy Loam On Rock	20 800	1 740	740	180	24 980	3 820	8 820
	Upland Timber Soils (600, 700, 800)							
634, 734	Yellow-Gray Silt Loam	25 020	2 220	880	320	37 030	6 680	10 280
635, 735	Yellow Silt Loam	16 230	1 730	890	290	35 610	9 370	9 270
874	Yellow-Gray Fine Sandy Loam	23 360	2 350	790	330	35 350	7 460	10 840
875	Yellow Fine Sandy Loam	12 620	1 510	870	290	35 150	9 670	12 230
	Terrace Soils (1500)							
1520	Black Clay Loam	83 380	7 600	2 160	1 220	28 160	15 480	54 980
1527	Brown Silt Loam Over Gravel	47 940	4 110	1 160	560	31 080	6 900	9 850
1536	Yellow-Gray Silt Loam Over Gravel	33 990	3 040	940	330	35 900	5 870	11 350
1526.1	Brown Silt Loam On Clay	54 260	4 280	1 220	560	33 900	7 660	11 320
1528	Brown-Gray Silt Loam On Tight Clay	63 410	6 210	1 910	800	33 970	5 960	9 370
1571	Brown Fine Sandy Loam	60 590	4 840	1 480	670	29 380	7 350	14 950
1550	Black Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1561	Black Sandy Loam	98 090	9 590	1 840	1 520	19 150	10 570	53 620
1560	Brown Sandy Loam	35 230	2 930	960	490	24 070	4 730	7 490
1568	Brown-Gray Sandy Loam On Tight Clay	38 560	3 320	1 000	380	21 380	4 240	5 680
1564	Yellow-Gray Sandy Loam	11 800	940	620	200	28 000	2 880	6 800
1581	Dune Sand	14 670	1 230	910	210	21 360	3 750	6 710
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	80 020	6 430	2 010	1 020	30 780	11 250	17 140
1454	Brown Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1451	Brown Loam	90 330	7 390	2 660	1 150	28 580	9 360	12 850
1460	Brown Sandy Loam	43 080	3 660	1 330	450	25 860	6 280	10 970
1420	Black Clay Loam	86 340	6 720	2 240	960	30 680	15 780	23 220
1445	Yellow Fine Sandy Silt Loam	27 280	2 080	1 080	460	36 320	9 620	21 360
1401	Deep Peat[2]	352 360	30 860	3 060	3 340	4 590	4 800	21 070
1402	Medium Peat On Clay[2]	167 520	16 610	1 150	2 350	9 030	4 400	20 340
1410	Peaty Loam	228 720	20 290	2 050	2 950	20 590	11 350	66 500
1450	Black Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]On account of the heterogeneous character of this soil type, chemical analyses are not reported.
[2]Amounts reported are for 1 million pounds of Deep Peat and Medium Peat On Clay.

By adding together the figures for all three strata we have an approximate invoice of the total plant-food elements within reach of most of our field crops, since practically their entire feeding range is included in the upper 40 inches. One of the most striking facts brought out of this consideration of the data is the great variation within a given soil type in the relative abundance of the

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF WHITESIDE COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (600, 700, 800)							
626, 726	Brown Silt Loam	59 310	5 290	2 000	490	69 530	20 050	20 720
871	Brown Fine Sandy Loam	51 580	4 420	1 960	540	67 260	19 120	23 360
876	Mixed Sand and Loess[1]	.....	.....	.....	.....	.....	.....	.....
660.5	Brown Sandy Loam On Rock	46 440	4 120	1 640	840	48 560	16 880	33 440
	Upland Timber Soils (600, 700, 800)							
634, 734	Yellow-Gray Silt Loam	16 140	2 010	1 710	470	76 750	20 530	19 960
635, 735	Yellow Silt Loam	12 920	1 670	1 990	290	70 160	21 630	18 880
874	Yellow-Gray Fine Sandy Loam	17 760	1 700	1 640	460	72 440	19 940	20 700
875	Yellow Fine Sandy Loam	10 600	1 470	2 030	360	70 040	21 800	24 830
	Terrace Soils (1500)							
1520	Black Clay Loam	81 000	7 360	3 320	1 400	58 280	30 200	86 200
1527	Brown Silt Loam Over Gravel	47 910	4 300	1 790	800	64 970	17 010	19 370
1536	Yellow-Gray Silt Loam Over Gravel	15 360	1 860	1 540	260	75 000	16 180	18 400
1526.1	Brown Silt Loam On Clay	70 120	5 480	2 120	360	71 520	17 400	21 920
1528	Brown-Gray Silt Loam On Tight Clay	36 020	3 440	2 900	1 350	77 060	13 740	17 200
1571	Brown Fine Sandy Loam	61 880	4 780	2 560	940	59 940	15 440	26 360
1550	Black Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1561	Black Sandy Loam	83 220	7 380	2 660	1 260	44 460	21 640	70 500
1550	Brown Sandy Loam	46 390	3 950	1 830	690	50 130	10 560	14 690
1568	Brown-Gray Sandy Loam On Tight Clay	21 240	2 160	1 040	440	52 320	11 720	11 760
1564	Yellow-Gray Sandy Loam	11 680	920	1 240	320	61 280	7 800	14 160
1581	Dune Sand	16 230	1 430	1 680	250	42 790	7 330	13 950
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	82 020	7 360	2 880	1 280	63 280	32 240	49 500
1454	Brown Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1451	Brown Loam	77 380	6 450	2 630	1 190	60 770	19 390	24 230
1460	Brown Sandy Loam	57 360	5 320	2 420	660	55 400	17 700	34 460
1420	Black Clay Loam	98 320	7 360	3 760	760	63 200	34 240	46 760
1445	Yellow Fine Sandy Silt Loam	52 560	4 080	2 480	1 040	72 120	21 120	40 960
1401	Deep Peat[2]	586 460	39 080	13 470	4 010	14 360	10 660	30 700
1402	Medium Peat On Clay[2]	216 080	19 600	1 570	2 350	9 030	4 400	20 340
1410	Peaty Loam	160 680	13 790	2 670	1 850	49 850	22 710	104 280
1450	Black Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of this soil type, chemical analyses are not reported.
[2]Amounts reported are for 2 million pounds of Deep Peat and Medium Peat On Clay.

various elements present as compared to the amounts removed by crops. For example, in the most extensive type in the county, Brown Silt Loam, Upland, we find that the total quantity of nitrogen in all three strata is 13,380 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus is only about half as much, or 6,100 pounds, but this amount is equivalent to the phosphorus in nearly three times as much corn, namely, 35,900 bushels.

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF WHITESIDE COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (600, 700, 800)							
626 726	Brown Silt Loam	28 300	3 240	2 900	510	103 040	38 810	38 870
871	Brown Fine Sandy Loam	26 550	2 880	2 850	240	102 180	33 570	40 950
876	Mixed Sand and Loess[1]							
660.5	Brown Sandy Loam On Rock	37 740	3 420	2 400	1 020	70 680	33 240	61 680
	Upland Timber Soils (600, 700, 800)							
634 734	Yellow-Gray Silt Loam	14 060	1 970	3 450	540	109 590	36 360	35 490
635 735	Yellow Silt Loam	11 920	1 620	3 480	160	108 860	36 540	36 040
874	Yellow-Gray Fine Sandy Loam	11 640	1 980	3 450	420	105 750	35 100	36 540
875	Yellow Fine Sandy Loam	18 640	1 640	3 580	280	105 540	42 360	63 340
	Terrace Soils (1500)							
1520	Black Clay Loam	51 660	4 440	3 960	960	93 780	45 300	70 140
1527	Brown Silt Loam Over Gravel	26 980	2 780	2 840	710	95 310	30 460	33 110
1536	Yellow-Gray Silt Loam Over Gravel	13 230	1 860	3 330	90	104 370	34 200	33 900
1526.1	Brown Silt Loam On Clay	54 300	3 960	3 240	120	106 500	65 100	38 700
1528	Brown-Gray Silt Loam On Tight Clay	21 210	2 610	3 510	230	111 660	32 640	32 970
1571	Brown Fine Sandy Loam	29 890	2 880	3 000	330	94 320	28 140	43 110
1550	Black Mixed Loam[1]							
1561	Black Sandy Loam	47 130	3 300	3 330	1 140	78 180	34 020	58 020
1560	Brown Sandy Loam	27 340	2 420	2 080	360	72 300	16 220	20 160
1568	Brown-Gray Sandy Loam On Tight Clay	18 960	2 220	1 800	420	82 380	26 940	23 220
1564	Yellow-Gray Sandy Loam	11 040	900	2 220	180	85 140	17 700	25 140
1581	Dune Sand	12 820	1 260	2 080	180	64 720	11 040	20 340
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	41 380	3 720	3 420	570	91 410	79 020	201 600
1454	Brown Mixed Loam[1]							
1451	Brown Loam	34 360	2 960	3 040	620	91 260	43 480	86 640
1460	Brown Sandy Loam	59 970	4 320	3 120	1 170	85 350	61 020	217 470
1420	Black Clay Loam	77 520	4 560	7 980	720	71 280	50 280	58 500
1445	Yellow Fine Sandy Silt Loam	172 020	13 620	5 400	2 160	110 220	37 560	52 020
1401	Deep Peat[2]	879 690	58 620	20 210	6 010	21 540	15 990	46 050
1402	Medium Peat On Clay	187 440	16 440	3 530	3 780	94 800	62 160	112 440
1410	Peaty Loam	61 560	4 160	5 200	1 200	87 120	37 800	86 860
1450	Black Mixed Loam[1]							

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of this soil type, chemical analyses are not reported.
[2]Amounts reported are for 3 million pounds of Deep Peat.

In the surface stratum, however, which is the zone of most intensive crop feeding, we find the relative amounts of nitrogen and phosphorus more nearly in accord with the rate of removal of these elements by crops. Here the nitrogen is equivalent to nearly 5000 bushels of corn, and the phosphorus to 7,000 bushels.

The total stock of potassium, amounting in this type to 206,690 pounds an acre, would furnish this element for more than one million bushels of corn.

Service of Chemical Analysis in Soil Improvement

The foregoing statements should not be taken to mean that it is possible to predict how long any certain soil could be cropped under a given system before it would become exhausted. Nor do the figures alone indicate the immediate procedure to be followed in the improvement of a soil. It must be kept in mind that the *amount* of plant food shown to be present is not the sole measure of the ability of a soil to produce crops. The *rate* at which some of these elements are liberated from insoluble forms and converted to forms that can be used by growing plants is a matter of at least equal importance, as explained on page 35, and is not necessarily proportional to the total stocks present. One must know, therefore, how to cope with the peculiarities of a given soil type if he is to secure the full benefit from its stores of plant-food elements and from applied fertilizing materials. In addition there are always economic factors that must be taken into consideration, since it is necessary for one to decide at how high a level of productive capacity he can best afford to maintain his soil.

The chemical soil analysis made in connection with the soil survey is seen to be of value chiefly in two ways. In the first place it reveals at once outstanding deficiencies or other chemical characteristics which alone would affect its productivity to a marked extent or point the way to corrective measures. It should be borne in mind, however, that fairly wide departures from the usual are necessary before the chemical analysis alone can be followed as a guide in practice without supplementary information from other sources. Examples of this use of soil analyses are the extremely low potassium content of peaty soils, soils containing only 300 to 400 pounds of phosphorus per acre, and chemical tests for lime need. It is quite probable that the results of the soil analysis are frequently misused by attempting to interpret small differences in amount of a certain plant-food element as indicative of similar differences in fertilizer need.

The second function of soil analysis is as an aid in the scientific study of soils from many angles, the ultimate aim of which is, of course, the more economical utilization of the soil for efficient crop production. Not only do chemical studies aid in determining the processes involved in soil development under natural conditions, but also in determining the effects of different soil management and fertilizing practices upon the soil and upon the utilization by crops of the plant-food elements involved.

DESCRIPTION OF SOIL TYPES

UPLAND PRAIRIE SOILS

The upland prairie soils of Whiteside county occupy 129.47 square miles, or 18.48 percent of the area of the county. They are found chiefly in the northeast quarter of the county. Relatively small areas are also found in a triangular-shaped body lying between Fulton and Erie.

These soils vary in color from black to light brown or grayish brown in the surface, and in texture from silts to sands. The subsoils of this group vary in compactness and other characters, as will be noted in the type descriptions to follow.

The dark color of the prairie soils is due to an accumulation of organic matter from the fibrous roots of the prairie grasses that grew on this land for centuries. A covering of fine soil and a mat of vegetative material by partially excluding the oxygen protected these roots from rapid and complete decay. From time to time the mat of old grass stems and leaves was partially destroyed by prairie fires and decay, but it was constantly being renewed, and while it added but little organic matter to the soil directly, it served to retard the decay of the roots of the grasses.

Brown Silt Loam (626, 726)

Brown Silt Loam as mapped occupies 93.28 square miles, or 13.31 percent of the area of Whiteside county. It is fairly uniformly distributed over the northern part of the county, with an isolated area occurring in the southwestern part adjacent to Henry county. At the time the soil map of this county was prepared, certain areas were classified as Brown Silt Loam which, in the light of more recent studies, would now be considered as not strictly a part of this type. These variations are noted in the following paragraphs.

The topography of the type varies from almost level to rolling, and associated with this variation is a variation in soil character. Erosion in relatively recent time has cut numerous deep gorges into the type between Rock and Elkhorn creeks, and these eroded areas are included in the type Yellow Silt Loam (635, 735). There are many long, gentle slopes, mapped as Brown Silt Loam, from which much soil material has been removed by erosion without forming gullies. Areas of this sort have not been differentiated on the map but they should be recognized in planning soil management and treatment, as they differ materially in their requirements from the more level-lying portions. Natural drainage is good thruout the type.

As previously stated, this soil was formed from wind-blown loessial material varying in depth from 5 to 15 feet or more. Near Mississippi river the loess deposit is deeper than in the eastern part of the county. In the region between East Clinton and Mineral Springs this type contains more fine sand than is commonly found in a silt loam. Some of the areas of Brown Silt Loam in this region probably should have been mapped as Brown Fine Sandy Loam, tho the separation is very difficult to make.

The A_1 horizon, which averages about 8 inches in depth, is a light brown to medium brown silt loam and contains an appreciable amount of fine sand. The A_2 horizon, extending to about 20 inches in depth, is a friable silt loam, varying in color from light brown to yellowish brown. The B horizon is about 12 inches thick and is a slightly compact, lightly mottled, yellow silt loam. Below 32 inches a friable, slightly mottled yellow silt loam occurs. It is spotted with occasional yellow or brown iron stains. On the lower, more nearly level areas the B horizon is more strongly mottled and more compact and its color is drabbish yellow or grayish yellow. In places where erosion has been active, sufficient loess material has been washed off from the surface so that the gravelly drift occurs within 40 inches of the surface and occasionally even on the surface.

Management.—In planning a system of management for this soil, the first consideration should be to provide for a regular supply of fresh leguminous organic matter. This is particularly necessary on the above mentioned areas where the slope is sufficient to permit erosion. It should be noted that even gentle slopes are subject to erosion, tho it is often not very noticeable unless gullies form. Sweet clover is an excellent legume to grow as a soil improver and it is also a good pasture crop. Before seeding sweet clover, the soil should be tested in detail to determine the amount of limestone needed. In general, this type requires about 2 tons an acre for either alfalfa or sweet clover; there are, however, many exceptions to this rule.

The Mt. Morris experiment field in Ogle county and the Dixon experiment field in Lee county are located on soil which, with the exception of a few areas, is similar to Brown Silt Loam as mapped in Whiteside county. These fields, which have been under full treatment since 1913 and 1912 respectively, are in agreement that manure gives very good increases in yield in a rotation of corn, oats, wheat, and clover. (The data from the Mt. Morris field will be found on page 48, and from the Dixon field on page 50.) The results show also that the plowing down of crop residues is a profitable practice and that limestone returns a large profit when used on this soil.

The evidence furnished by these fields regarding the value of rock phosphate is consistent in showing that when manure is used, rock phosphate does not cause as much increase in yield as when no manure is used and crop residues are depended on as a source of organic matter. If we average the two fields, we find that the application of rock phosphate in addition to manure has barely caused sufficient increase in yield to pay for the application of half a ton of rock phosphate once in the rotation, while in the residues system the increase has been sufficient to pay a small profit on this rate of application. The question arises as to whether a half-ton application would cause as much increase in yield as the one-ton application, which was the amount used in these experiments; but no data are available upon which to base an answer to this question. It is suggested that those who wish to increase their acre yield and thus make possible the cultivation of fewer acres try rock phosphate on a few acres, together with the minimum amount of limestone which it is thought can be used. Acid phosphate is a standard phosphatic fertilizer which it would also be well to try. This material should be applied chiefly, if not entirely, for the wheat crop. The application should be made after plowing, and before working down the seed bed, at the rate of about 300 pounds an acre. If the wheat drill is provided with a fertilizer attachment, the acid phosphate may be applied at the time of seeding the wheat.

It should be remembered that no phosphate can be expected to give satisfactory returns unless sufficient nitrogen is present and the soil is in good physical condition. In general farming, the acre returns are not sufficiently high to justify the purchase of commercial nitrogen at its present price. It is therefore necessary to depend on legumes for the nitrogen supply; and of the legumes, sweet clover ranks highest as a source of nitrogen and organic matter.

The use of potash is not advised on this soil since the evidence indicates that it would not cause sufficient increase in yield to pay for its cost.

Brown Fine Sandy Loam (871)

Brown Fine Sandy Loam, Upland, occupies practically 10 square miles, or 1.43 percent of the area of the county. Practically all of this type is found in the region extending from East Clinton to Mineral Springs, west of Cattail slough.

The topography of this type varies from undulating to rolling. The area becomes more rolling south of Albany where, with minor exceptions, the wind has reworked the soil material. Drainage is good thruout the type. The texture and compactness of the subsoil vary somewhat. On the flat areas it is much heavier and more compact than on the rolling areas.

The A_1 horizon, which is about 8 inches in depth, is a light brown to medium brown fine sandy loam. The A_2 horizon, extending to a depth of 18 or 19 inches, varies from a light brown to yellowish brown fine sandy loam. The B horizon is a slightly mottled, yellow fine sandy or silt loam. It varies in texture and compaction as above noted but is never excessively heavy or compact. At a depth of about 30 inches a friable, slightly mottled, yellow fine sandy loam or silt loam occurs. This material contains carbonates at a depth of 40 to 50 inches. The areas of this type which are adjacent to the type Mixed Sand and Loess have not developed any well-defined horizons, indicating that the deposition of this soil material by the wind has taken place within very recent times.

Management.—Brown Fine Sandy Loam shows a slight to medium acidity and in general should have an application of 1½ to 2 tons of limestone an acre before the growing of alfalfa or sweet clover is attempted. Before applying limestone, however, each field should be tested in detail, for there is considerable variation in the degree of acidity.

This soil is relatively low in organic matter and nitrogen. These deficiencies should be taken care of by growing legumes at regular intervals in the rotation and by the application of all manure available. Because of its physical properties, Brown Sandy Loam favors the deep penetration of roots, thus greatly increasing the feeding range of plants over that in a soil having a relatively impervious subsoil.

As a guide to the treatment of this type we may go to the records of the Union Grove experiment field, which was located on a soil sufficiently similar for the results to be of value. On this field a rotation of corn, corn, oats or barley, and clover was grown. The results, which will be found on page 52, show high returns from the use of crop residues and very high returns from the use of manure. Potassium applied in the form of sulfate of potash gave good results in the residues system, but on the manure plots the increases following its application were not sufficiently high to justify its use. Rock phosphate did not cause sufficient increase in the crops in this rotation to pay for its cost even if used at the rate of half a ton once in the rotation. A nine-year rotation of potatoes and alfalfa was established on another series of plots. The results of this work indicate that rock phosphate may be used profitably for alfalfa on this soil.

The following specific suggestions may be made for the treatment of Brown Fine Sandy Loam, based largely on results from the Union Grove experiment field. ***First,*** apply only sufficient limestone to grow the crops which it is desired to grow.

If alfalfa or sweet clover is to be grown, more limestone will have to be used than if red clover is the legume to be grown. The assistance of the farm adviser should be secured in making a detailed test of each field before applying limestone. *Second,* make full use of all available manure and plow down all crop residues with the possible exception of wheat, oat, and barley straw. *Third,* apply 100 to 150 pounds of a potash salt for corn. *Fourth,* if alfalfa is grown, apply one ton of rock phosphate or about 600 pounds of acid phosphate an acre and work it into the soil thoroly as the seed bed is being prepared.

Mixed Sand and Loess (876)

Mixed Sand and Loess, as the name indicates, is variable in character. It owes its mixed composition and variable character to the deposition by the wind, during remote times, of material of varying texture. The final deposit was fine in texture. Subsequent erosion, either by wind or water, removed this fine loess covering in some places and not in others, and as a result a mixed soil was formed. The areas of different texture are so small that they cannot be differentiated successfully on the soil map and are therefore all grouped together as one type.

Mixed Sand and Loess occurs in the northwestern part of Whiteside county, occupying a total of 25.91 square miles. The topography varies from billowy to rough and broken, the latter condition being found adjacent to the Mississippi bottom. Both surface drainage and underdrainage are good on this type.

The diverse character of this type makes it impossible to give more than a generalized profile description. The surface soil varies in depth, color, and texture, but in general is friable and easily worked. In places it is too coarse in texture to be a good general-purpose soil. The subsurface varies as greatly as does the surface and no true subsoil is present because the soil materials have not been exposed to the soil-forming forces sufficiently long for a compact zone to be developed.

Management.—Mixed Sand and Loess is not a unit with respect to management requirements. The reader is referred to Brown Fine Sandy Loam, page 17, for a discussion of the management of the finer-textured portions of this type and to Brown Sandy Loam, Terrace, page 24, or Dune Sand, Terrace, page 25, for management suggestions for the coarser portions of the type.

Brown Sandy Loam On Rock (660.5)

Brown Sandy Loam On Rock is a type of little importance. A small area of 186 acres is found just east of Albany.

The surface soil, which extends to about 7 inches in depth, is a brown sandy loam. The subsurface is a medium-grained brown sandy loam resting on limestone rock, which occurs at a depth of 12 to 24 inches below the surface.

This type is used chiefly for pasture and is suited for nothing else because of its shallowness.

UPLAND TIMBER SOILS

The upland timber soils are found in the northern and western parts of Whiteside county. They are characterized in color by a grayish yellow surface

soil. The long-continued growth of forest trees on these soils has been chiefly responsible for their low organic-matter content. This group of soils occupies 128.47 square miles in Whiteside county.

Yellow-Gray Silt Loam (634, 734)

Yellow-Gray Silt Loam occurs as an outer light-colored soil belt bordering the stream courses. Its topography varies from undulating to rolling. Natural drainage is good, and with reasonable care and good farming methods, little difficulty should be encountered with washing and gullying. This type occupies 26.65 square miles, or 3.80 percent of the area of the county.

In the vicinity of Elkhorn and Rock creeks the light color of certain areas has resulted largely from removal of the surface soil by erosion rather than from timber growth. These areas are shown on the map as Yellow-Gray Silt Loam, tho they differ somewhat from the type.

The A_1 horizon, which is about 6 inches thick, varies from a brownish yellow to a grayish yellow silt loam. The A_2 horizon extends to about 18 inches and is a friable, mottled, yellow silt loam, floury in texture. The B horizon, extending to about 30 inches, is a friable, slightly compact, strongly mottled, yellow silt loam. The C horizon is a friable, somewhat mottled, yellow silt loam, spotted with brown and red iron concretion stains. Those areas of the type which are nearly level have a much grayer A_2 horizon and a more compact B horizon than described above.

Management.—Yellow-Gray Silt Loam is acid, tho not strongly so. In general, about 2 tons of limestone an acre are required for sweet clover or alfalfa.

This type is particularly in need of nitrogen and fresh organic matter. Sweet clover is the best source of these materials. It may be used to advantage as a pasture crop the fall of the first year and then as a green-manure crop for corn the spring of the second year. Some areas of this type are so rolling as to erode badly and should, if possible, be kept in permanent pasture.

Yellow Silt Loam (635, 735)

Yellow Silt Loam occurs mainly in the northeastern portion of the county, with a few isolated areas north of Morrison. If washing has not been active for a few years, the surface soil is brownish yellow in color. On some of the steep slopes glacial drift is exposed, but for the most part the material to a depth of 40 inches is loess. The type occupies a total area of 38.48 square miles.

Management.—This type should be utilized, for the most part, for permanent pasture, timber, or orchards. If it is cultivated, particular attention must be given to controlling run-off, if ruinous erosion is to be prevented. Terracing may be used to advantage in many cases as a means of lessening erosion, particularly when laying off a field for planting to orchards. For an account of experiments to prevent erosion on land of this character, the reader is referred to page 57, where the work conducted for nine years on the Vienna field in Johnson county is described.

Yellow-Gray Fine Sandy Loam (874)

Yellow-Gray Fine Sandy Loam occurs adjacent to the Mississippi river bluffs. It cover 27.58 square miles, or about 4 percent of the area of the county. It is undulating to rolling in topography. The surface drainage and underdrainage of the type are good.

The A_1 horizon, which is about 6 inches thick, varies from a brownish yellow to grayish yellow fine sandy loam. The A_2 horizon is a yellow fine sandy loam. The B horizon, occurring below 16 or 18 inches, is a yellow, fine sandy silt to sandy loam.

Management.—The type is acid, tho usually only slightly so. Carbonates occur at a depth of 50 to 60 inches. This type is similar to Yellow-Gray Silt Loam, but is much more permeable because of its coarser texture and more friable nature. The reader is referred to Yellow-Gray Silt Loam, page 19, for suggestions regarding the management of Yellow-Gray Fine Sandy Loam.

Yellow Fine Sandy Loam (875)

Yellow Fine Sandy Loam occurs in the western part of the county but not immediately adjacent to the Mississippi river bottoms. It covers an area of 35.76 square miles. In topography the type is rolling to hilly but the slopes are not so steep as in the case of the eroded silt loam types. On a part of the type deep gullies have been formed by long-continued erosion. Following the removal of the timber from these slopes, they were farmed intensively with no provision made for returning organic matter, with the result that much of this land has been seriously injured. There is, for the most part, no true surface or subsurface present because they have been eroded away. A thin surface soil, from 3 to 4 inches in depth, however, has been developed over small areas where the growth of grass has protected the soil from erosion.

Management.—The type, because of its topography, should be used for pasture, orchards, or timber. The depth to carbonates varies greatly. Alfalfa and sweet clover can often be grown successfully on the more gentle slopes without the addition of limestone. Where limestone is needed for the growing of legumes, the amount to be applied should be determined by careful examination. The assistance of the farm adviser or the Agricultural Experiment Station can be secured in making this determination. If it is necessary to farm a portion of this type, great care should be used to reduce erosion to the minimum, otherwise the removal of the surface will be so rapid as to keep the land in a state of low productivity. This soil is particularly deficient in nitrogen and organic matter and the first step in building it up should be to provide for a regular supply of fresh leguminous organic matter, preferably sweet clover.

TERRACE SOILS

About 39 percent of Whiteside county is a terrace formation. The immense alluvial fill which constitutes the terrace was deposited by flowing waters during glacial times. Finer-textured, wind-blown material was later deposited on the sandy, gravelly, terrace material. This finer material constitutes the mineral portion of the soils as they now exist.

Brown Silt Loam Over Gravel (1527)

Brown Silt Loam Over Gravel occupies 73.97 square miles, or 10.55 percent of the area of the county. It occurs principally north of Rock river. The topography is undulating except where sandy ridges occur, giving the surface a billowy appearance. Drainage is usually good, altho isolated areas occur which are poorly drained because of the presence of a thin layer of relatively impervious material in the subsoil. There is an appreciable amount of fine sand present thruout the type because of the deposition of this material by the wind upon the terrace.

The A_1 horizon, which is about 8 inches in thickness, varies from a light brown to dark brown silt loam. The A_2 horizon extends to a depth of 19 inches and is a yellowish brown silt loam. The B horizon is a yellow silt loam or fine sandy silt loam and contains some gray and drab splotches. The C horizon begins at about 32 inches and is ordinarily a slightly mottled, friable, yellow sandy loam. The depth to the sand and gravel substratum varies from 4½ to 8 feet.

Management.—A large proportion of this type is not acid and in only a few cases was it found to be more than slightly acid. It is a productive, easily worked soil and is adapted to any of the farm crops common to the region. Provision should be made for the systematic addition of leguminous organic matter to this soil. Sweet clover is unexcelled for this purpose and can be used to good advantage as a combination pasture and green-manure crop by pasturing it in the fall of the first year and plowing it down for corn in the spring of the second year. If it is shown by tests that the soil is acid, an application of limestone should be applied before attempting to grow sweet clover or alfalfa.

Yellow-Gray Silt Loam Over Gravel (1536)

Yellow-Gray Silt Loam Over Gravel occurs chiefly just north of Sterling, along Elkhorn creek, and just north of Morrison, along Rock creek. It covers a total area of 3.70 square miles. The type is flat to undulating in topography. Underdrainage is good because of the presence of a sandy, gravelly substratum.

The A_1 horizon to a depth of about 6 inches is a brownish yellow to grayish yellow silt loam. The A_2 horizon, about 12 inches in thickness, is a slightly grayish yellow silt loam. The B horizon, extending to a depth of about 30 inches, is a fairly compact, lightly mottled, yellow, silty clay loam. The C horizon is a friable, mottled, yellow silt loam, spotted with brownish yellow and red iron stains. It rests upon a sandy, gravelly subsoil which varies in depth from 45 to 60 inches below the surface.

Management.—The acidity tests made on this type indicate in general the need for an application of limestone at the rate of about 2 tons an acre for sweet clover. This soil is well adapted to alfalfa following the application of limestone. Experience indicates that the application of one-half to one ton of rock phosphate for alfalfa is a profitable practice; or acid phosphate may be used, applying it after plowing at the rate of 600 or 800 pounds an acre. Following the increase in the nitrogen and organic matter in this soil thru the use of legumes, any of the general farm crops common to the region may be grown successfully.

Brown Silt Loam On Clay (1526.1)

Brown Silt Loam On Clay occupies a total of only 1.55 square miles in Whiteside county. The largest area is located southwest of Prophetstown. The topography is flat, and effective underdrainage cannot be secured because of the presence of the impervious clay layer.

The A_1 horizon, which is about 9 inches in thickness, is a medium to dark brown silt loam with a grayish cast after the soil has become thoroly saturated and then dried. The A_2 horizon, extending to about 21 inches in depth, varies from a brown or yellowish brown silt loam to a grayish brown silt loam. The B horizon, extending to a depth of about 34 inches, is a very sticky and compact, mottled, reddish yellow to drabbish yellow clay. The C horizon, below 34 inches, is a less compact, slightly friable, mottled, yellow silt loam.

Management.—This type is medium acid and should have an application of at least 2 tons of limestone per acre. Surface drainage by means of open furrows and ditches is necessary. Sweet clover should be grown and plowed under the spring of the second year for corn.

Brown-Gray Silt Loam On Tight Clay (1528)

Brown-Gray Silt Loam On Tight Clay occupies 4.17 square miles in Whiteside county. Nearly all of the areas of this type are located south of Prophetstown. It occurs in depressions or pockets that are not well drained.

The A_1 horizon is about 7 inches in thickness and is a grayish brown silt loam. The A_2 horizon, extending to a depth of about 17 inches, is a brownish gray to gray silt loam. The B horizon is a sticky, plastic, compact, drab to gray clay. The C horizon occurs below 28 or 30 inches. It is a gray to drab silt loam or silty clay loam spotted with yellow iron stains.

Management.—This type is strongly acid and should receive about 4 tons of limestone per acre. Surface drainage must be depended on to remove excess water. Sweet clover should be grown regularly. If handled in this way, Brown-Gray Silt Loam On Tight Clay will produce reasonably good crops of corn or the small grains.

Brown Fine Sandy Loam (1571)

Brown Fine Sandy Loam, Terrace, occurs most extensively in the terrace south of Rock river. The type lacks uniformity because of the wind deposition of the soil material. It varies in topography from slightly undulating to billowy. The type occupies 13.56 square miles.

The A_1 horizon is a light brown to a medium brown fine sandy loam, varying in thickness from about 4 to 9 inches. The A_2 horizon, where distinguishable, varies from a light brown or yellowish brown fine sandy loam to a sandy silt loam. The B horizon, extending from about 20 to 32 inches is in general a slightly compact, bright yellow, fine sandy silt loam or sandy loam. The C horizon below 32 inches is a friable, grayish yellow to yellow fine sand.

Management.—This type varies in acidity but ordinarily the surface is only slightly acid, while the lower horizons usually show a stronger acidity than the surface. It is a productive, easily worked soil and the friability of the subsoil

favors deep root penetration. The organic-matter and nitrogen contents should be increased thru the growth of legumes.

Black Mixed Loam (1550)

Black Mixed Loam, Terrace, occurs in the low-lying, poorly drained areas in the terrace and might properly be included in the swamp and bottom-land group instead of in the terrace group. The type covers 27.87 square miles, or 3.98 percent of the area of the county. Its topography is flat but drainage is fairly well provided for by means of tile and open dredges. The streams in some of these dredge ditches are sluggish, owing to lack of proper fall and to the filling of the channels with silt and fine sand.

The mixed nature of this type makes it impossible to write a description that will apply to the type as a whole. The surface varies from a brown or black silt loam to a black sandy clay loam or peaty loam. The subsurface varies in like manner but is usually somewhat heavier than the surface. The subsoil is generally a plastic, compact, mottled, yellowish drab or drab clay loam. The subsoil is underlain with sand or gravel.

Management.—This type is, for the most part, productive when properly drained. Alkali occurs on some of the areas in sufficient concentration to be harmful. When such is the case, an application of potash will usually correct the condition. This soil is, for the most part, well supplied with nitrogen and organic matter, but provision should be made for plowing down some leguminous material at regular intervals.

Black Sandy Loam (1561)

Black Sandy Loam occurs in the terrace near Tampico. It occupies a total area of 22.36 square miles in Whiteside county. It is a type which has been developed under poor drainage and now occupies low-lying, nearly level areas. Within recent years most of the areas have been provided with drainage by means of tile, dredge ditches, and shallow, open ditches. One difficulty encountered in draining this type is the filling of the ditches because of the loose character of the soil material and the small slope.

The A_1 horizon, which is about 10 inches in thickness, is a black sandy loam. With drainage and cultivation, the color of this horizon changes with relative rapidity to brown because of the oxidation of the organic matter. The A_2 horizon, extending to about 22 inches, varies from a yellowish brown sandy loam to black sandy loam. The B horizon is a fairly compact, mottled drab or yellowish drab clay loam with a mixture of silt, sand, and clay in varying proportions. This horizon is stained with yellow and red iron concretions. The C horizon, which occurs at a depth of about 34 inches, is a drab or gray sandy loam or sand.

Management.—The organic matter and nitrogen are both low in this type. The lower horizons usually show somewhat more acidity than the surface and it is therefore advisable to apply somewhat more limestone than the test of the surface indicates. In general, about 2 tons of limestone an acre is needed. Following the application of limestone, legumes should be given a regular place in

the rotation. Sweet clover is an excellent legume for this soil, both as a pasture and soil-improving crop.

This type has a tendency to be drouthy. This fact makes it better adapted to small grain than to corn.

Brown-Gray Sandy Loam On Tight Clay (1568)

Brown-Gray Sandy Loam On Tight Clay occurs south of Rock river. Fortunately it is not extensively developed, occupying a total of about 4¼ square miles. It is found on areas slightly lower than those of adjacent soil types. It is flat in topography and is not well drained.

The A_1 horizon, which is about 8 inches in thickness, is a grayish brown sandy loam. The A_2 horizon, extending to a depth of about 22 inches, is a gray sandy loam. The B horizon, which is 8 or 9 inches in thickness, is a plastic, compact, gray sandy clay. The material below 30 or 32 inches is a medium-grained sand, drabbish gray to white in color, and spotted with yellow and red iron stains.

Management.—Additional drainage is necessary in many of the areas of this type. In placing tile, the joints must be carefully made in order to keep out silt and fine sand which are particularly troublesome in this type. Black Sandy Loam is commonly alkaline and in many areas the alkali is sufficiently concentrated to be harmful. This unfavorable condition can be remedied by using potash. The organic-matter content of this type is still high in most of the areas but it is resistant to decay and therefore the addition of fresh leguminous material is beneficial.

Brown Sandy Loam (1560)

Brown Sandy Loam, Terrace, is extensively developed and fairly well distributed over the terrace with extensive areas in the southeastern part of the county. It occupies 86.57 square miles, or practically ⅛ of the area of the county. Its topography varies from flat to slightly undulating, the irregularity being due to the formation of low sand dunes over which finer material has been deposited. Drainage of the type is, for the most part, good.

The A_1 horizon, which is about 8 inches in thickness, is a brown sandy loam. The A_2 horizon, extending to 19 or 20 inches in depth, is a yellowish brown sandy silt loam or sandy loam. The B horizon is a friable yellow sandy loam or sand, becoming an incoherent mass of yellow sand below 32 to 35 inches.

Management.—Furrows and open ditches must be depended on for the drainage of this type. Most of it requires 3 or 4 tons of limestone an acre. Sweet clover does well following the limestone application.

Yellow-Gray Sandy Loam (1564)

Yellow-Gray Sandy Loam, is undulating in topography and is found in small areas along Rock river. The type occupies a total of only 461 acres. It is similar to Yellow-Gray Silt Loam Over Gravel except that it is coarser in texture. The areas of this type are so small that ordinarily they should be managed in the same way as the adjoining types.

Dune Sand (1581)

Dune Sand is widely distributed thruout the terraces in Whiteside county. The dunes vary in altitude from 2 or 3 feet to 25 or 30 feet above the adjacent types and cover a total area of 33.25 square miles. Many "blowouts" have been formed where the wind has had an opportunity to drift the sand. The topography varies from undulating to billowy or rolling.

The surface in places shows a slight accumulation of organic matter and in general is a brownish yellow sand. This darker surface may extend to a depth of 3 or 4 inches. Below this thin surface horizon the material is an incoherent mass of yellow sand.

Management.—This type in its natural condition represents, for the most part, a barren waste. It varies somewhat, however, in its potential agricultural value according to the texture of the sand. There are portions of the type that

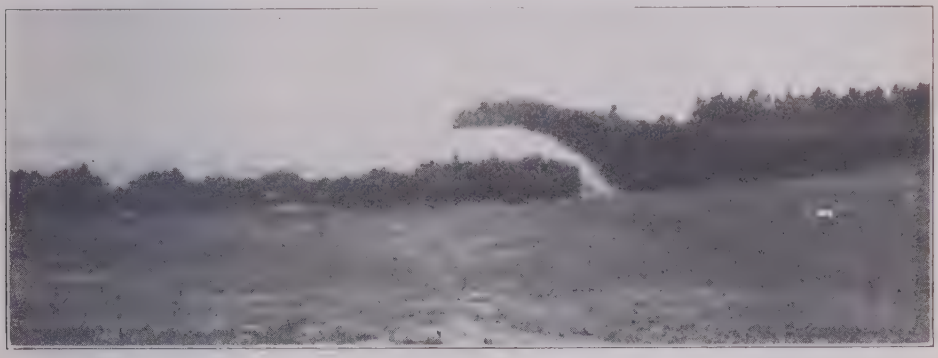

FIG. 2.—RECLAIMING A SAND DUNE THRU REFORESTATION

At one end of the dune seen in the distance the barren waste of shifting sand has been transformed into a fine grove of trees while the other portion of the dune remains in its natural desolation. This is the work of Mr. A. N. Abbott, of Morrison, Illinois.

are susceptible of considerable improvement thru soil treatment, as demonstrated on the Oquawka experiment field in Henderson county. On this field fair crops of corn, wheat, rye, soybeans, alfalfa, and sweet clover are being produced by the application of limestone and organic manures. The results of this work on the Oquawka field are discussed in greater detail on page 59.

Even the shifting dunes, which are ordinarily considered as absolutely waste land, have been shown to be susceptible of reclamation thru forestation. In Section 31, Township 22 North, Range 4 East, reforestation has been thoroly demonstrated as a success. Following the planting of locust trees, blue-grass starts and does well, increasing the pasture value of the land many times.

Black Clay Loam (1520)

Black Clay Loam, Terrace, is a minor type in Whiteside county. It occupies a total of only 109 acres and occurs in small, scattered areas. The topography is flat. Drainage is fair.

The A_1 horizon, which is about 7 inches thick, is a plastic, black clay loam. The A_2 horizon, 8 to 18 inches, is a plastic, drabbish black to drab clay loam. The

B horizon, to a depth of about 32 inches, is a plastic, fairly compact, drabbish black clay, spotted with red iron concretions. Below 32 inches, a fairly plastic, friable, grayish drab to drab sandy clay or clay loam occurs. It is strongly spotted with yellow and brown iron stains.

Management.—Black Clay Loam, Terrace, is frequently alkaline. The alkali may or may not be sufficiently concentrated to require the use of potash to overcome its harmful effects. It is essential to maintain a good supply of organic matter in this soil, otherwise it becomes very difficult to farm.

SWAMP AND BOTTOM-LAND SOILS

This group includes the bottom lands along Mississippi and Rock rivers and their tributaries, and the swamps and poorly drained lowlands. The soil material is of alluvial origin, and the land is largely subject to overflow. These swamps were once lakes or a part of the preglacial river channels. The total area of this group, consisting of ten soil types, is 161.56 square miles, or nearly one quarter of the area of the county.

Deep Brown Silt Loam (1426)

Deep Brown Silt Loam occupies a total area of 28.53 square miles in Whiteside county. Practically all of this type is located along Rock river and south of Cattail slough. The topography of this type is not so uniformly flat as is common for bottom-land soil because of the presence of long depressions which mark previous stream beds.

Deep Brown Silt Loam does not show distinct horizon development because of its youth. The surface varies considerably in color and texture but in general is a brown silt loam. At a depth of 8 or 10 inches the texture becomes finer and the color darker, and ordinarily a drab color appears at about 30 inches in depth. The drab-colored material is discolored with reddish yellow iron stains.

Management.—This type for the most part is subject to overflow. It needs no treatment other than good tillage. It is a productive soil and its productivity is maintained by the sediment deposited at each overflow.

Brown Mixed Loam (1454)

Brown Mixed Loam occupies 24.07 square miles, or 3.43 percent of the county and is found for the most part along the small streams. This type, as mapped, is made up of a number of distinct soils varying in texture from silts to sandy loams and in color from grayish yellow to brown or black. It is not practicable to separate these various soils because they occur in very small areas and also because much of the type is subject to overflow and is being constantly changed.

Management.—Brown Mixed Loam is a good soil but it is not so consistently good as Deep Brown Silt Loam because of the presence of patches of sandy soil. Since it is subject to overflow, no fertilizer treatment is advised.

Brown Loam (1451)

Brown Loam is the most extensive bottom-land type in Whiteside county. It occupies a total of 33.78 square miles and occurs for the most part along Rock

river below Prophetstown. The topography of this type is flat to slightly undulating. The irregularities in topography are due to the work of streams during periods of overflow. The type, as mapped, is rather diverse and therefore only a very generalized description of it is possible. It is only within recent years that Brown Loam has been placed under cultivation.

The surface soil to a depth of 5 or 6 inches is commonly a brown loam, but varies from silt loam or clay loam to fine sandy loam. Below this surface 5 or 6 inches the material is usually somewhat lighter in color and varies greatly in texture. At a depth of about 18 or 20 inches a rather compact and plastic drab or black clay loam occurs. This heavy layer is ordinarily not over 6 or 8 inches thick. Below this heavy layer the material is sandier and at a depth of 28 to 32 inches gray, white, or yellow sand occurs.

Management.—The type drains fairly well if suitable outlets can be obtained. Many areas are left in permanent pasture; however, some portions of the type give good returns when cropped. The periodic overflows usually cover this with sediment; therefore no fertilizer treatment is advised.

Brown Sandy Loam (1460)

Brown Sandy Loam, Bottom, occurs along the Mississippi and Rock rivers and occupies a slightly higher elevation than the adjacent bottom-land types. The type covers a total area of practically 23 square miles. Its topography varies from flat to slightly undulating. The undulations are due to wind action which piles the sandy material in low ridges.

Horizons are not well developed over much of this type and it is rather diverse in character. The surface is commonly brown sandy loam and below the surface layer the material becomes sandier. Coarse sand or gravel is not uncommon at a depth of 35 to 45 inches.

Management.—This type varies in acidity. Some portions of it require no limestone and ordinarily not over 2 tons are required where it is acid. Overflow is common. Areas which are not subject to overflow may be managed as advised for Brown Sandy Loam, Terrace, page 24.

Black Clay Loam (1420)

Black Clay Loam, Bottom, occurs in the western part of the county and occupies a total of only 2.41 square miles. It is flat in topography and occurs in depressions in the bottom land. Its drainage is poor on account of the lack of proper outlets.

The surface, to a depth of about 7 inches, is a black silty clay loam or clay loam. Below this surface layer, a plastic, black clay loam usually occurs. At a depth of about 18 or 20 inches the color is drabbish black, and at about 30 inches it is gray or drab.

Management.—This type contains alkali, frequently in sufficient amounts to be harmful to crops. When this condition exists, potash may be used to correct it. Particular care should be used in maintaining a good supply of fresh organic matter, as this heavy soil is rather difficult to keep in good physical condition. Additional drainage is necessary on some of the areas.

Yellow Fine Sandy Silt Loam (1445)

Yellow Fine Sandy Silt Loam, commonly called "bluff wash," occurs as outwash from the upland loessial deposits. It is a recent formation and occurs as a fan-like deposit on the bottom land at the mouth of small streams. This type occupies a total area of 6.64 square miles. The topography is usually gently sloping and drainage is fair.

This deposit is so recent that little or no horizon development can be observed with the exception of a slight darkening of the surface to a depth of 6 or 8 inches. The color of the surface is light brown or yellowish brown. The texture of the deposit is variable but is usually a fine sandy silt loam.

Management.—This type is well supplied with carbonates and is an excellent alfalfa and sweet clover soil. It is not well supplied with nitrogen and organic matter but these constituents are easily built up because of the calcareous nature and productivity of the type. No fertilizer treatment is advised, at least until a good organic-matter supply has been built up thru the use of clovers.

Deep Peat (1401)

Deep Peat occupies 14.6 square miles, or about 2 percent of the area of the county. The largest area is found in Cattail slough extending from east of Fulton to Fenton Junction in what was originally an old channel of the Mississippi river. The type is flat in topography and originated in low-lying areas which were continuously wet, thus favoring the growth and accumulation of organic matter.

The surface to a depth of about 6 inches is black, well-decomposed peat containing charred remnants of sedges. The material below this surface layer to a depth of about 22 inches is usually a light brown, finely fibrous peat containing bands of shells. Below this depth the color is reddish brown and the plant material is well preserved.

Management.—The first consideration in bringing an area of Deep Peat under cultivation is that of providing good drainage. Potash is needed on this soil, and potassium sulfate at the rate of 100 to 150 pounds an acre may be applied for corn just before planting.

Deep Peat is a good trucking soil and is used extensively for that purpose. For results of field experiments on this type see the account of Manito field, page 61.

Medium Peat On Clay (1402)

Medium Peat On Clay is of minor importance in Whiteside county, the type occupying a total of less than one square mile.

The surface, to a depth of about 2 inches, is well-decomposed black peat. Below this depth the color is usually brown. The clay substratum occurs at a depth of 15 to 30 inches. The upper part of the clay is black in color and the lower part, usually starting at a depth of 25 to 35 inches, is gray.

Management.—Good drainage must be provided for this type. It is not so deficient in potash as is Deep Peat, but this material is frequently needed because

of alkali. No special treatment other than improvement of the drainage and use of potash on the alkali spots is advised for the present.

Peaty Loam (1410)

Peaty Loam occupies nearly 20 square miles and, as mapped, is widely distributed thruout the terraces. The type was formerly swampy, poorly drained, and uncultivated. Within recent years tile and dredge-ditch drainage, together with cultivation, have promoted rapid decay of the peaty material. This, together with the deposition of sand from adjacent sandy areas, has resulted in changing many areas of the type to Black Sandy Loam or even to Brown Sandy Loam. However, some areas of true Peaty Loam still remain.

On the remaining areas of Peaty Loam the surface to a depth of about 6 inches is peaty loam. Below this surface stratum to a depth of about 20 inches the material varies from peaty loam to black sandy loam. Below 20 inches slightly compact, gray to yellow sand with some clay and silt occurs, while below 30 inches the material is usually grayish yellow or yellow sand.

Management.—Peaty Loam is usually alkaline, and potash is needed. Potassium chlorid or potassium sulfate should be applied for the corn crop at the rate of 100 to 150 pounds an acre. No treatment in addition to this is advised for the present. The field experiments at Tampico are of interest in this connection and an account of them is given on page 63.

Black Mixed Loam (1450)

Black Mixed Loam, Bottom, was formed in low, poorly drained areas. Within recent years most of the areas of this type have been drained so that crops can be grown on them. The type occupies a total area of 8.28 square miles.

The surface, extending to a depth of about 8 inches, varies from black clay loam to black sandy or peaty loam. Below this to a depth of about 24 inches the material varies from black silt loam to black clay loam and contains an appreciable amount of sand. Plastic, drab clay occurs below about 24 inches.

Management.—Black Mixed Loam is, for the most part, productive. It contains patches of alkali and some areas are not well drained. These poorly drained areas are left in permanent pasture.

RESIDUAL SOILS

Rock Outcrop (099)

Limestone Outcrop occupies a total area of 77 acres in Whiteside county. It occurs, for the most part, along the Mississippi river bluffs. For further information concerning limestone in Whiteside county, the reader is referred to Bulletin No. 46, Limestone Resources of Illinois, issued by the State Geological Survey, Urbana.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items, such as native vegetation (whether timber or prairie), topography, and geological origin and formation, may assist in the differentiation of types, altho they are not fundamental to it.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a mature soil, three horizons designated as A, B, and C are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the A horizon.

C designates the layer lying below the B horizon and in which the material has been less affected by the weathering processes.

Frequently differences within a stratum or zone are discernible, in which case it is subdivided and described under such designations as A_1 and A_2, B_1 and B_2, etc.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in differentiating soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made provided the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of this report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over," for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinois glaciations
300 *Lower Illinoisan glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation

1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* formed by material derived from the Illinoisan or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the remainder of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to the last of November. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction.

Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed from the soil by growing plants, including manganese, silicon, sodium, aluminum,

chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	....	....	4.00	....	....	....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	....	.75	.25	.13	....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5.
[2]Young second-year growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of

crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous

acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the

surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

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[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4, have been found satisfactory. Some commercial firms are also offering other potassium thiocyanate solutions which are satisfactory.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) contains 1 pound of nitrogen.
1 bushel of corn (grain and stalks) contains 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) contains 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogeneous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, acid phosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate, and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid

phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average livestock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern

and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increase the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as

grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months, as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop be corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the better adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year—Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year—Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed; or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

The two following rotations are suggested as especially adapted for combating the corn borer:

First year —Corn
Second year—Soybeans
Third year —Small grain (with legume)
Fourth year—Legume
Fifth year —Corn (for silage)
Sixth year —Wheat (with sweet clover)

First year —Corn
Second year—Soybeans
Third year —Small grain (with legume)
Fourth year—Legume
Fifth year —Wheat (with alfalfa)
Sixth year —Alfalfa

Five-Year Rotations

First year —Corn
Second year—Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year—Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year—Soybeans
Third year —Corn
Fourth year—Wheat (with legume)
Fifth year —Legume

First year —Corn
Second year—Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year—Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field rotating over all fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year—Wheat or oats (with clover)
Third year —Clover
Fourth year—Wheat (with clover)

First year —Corn
Second year—Corn
Third year —Wheat or oats (with clover)
Fourth year—Clover

First year —Corn
Second year—Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year—Clover

First year —Wheat (with clover)
Second year—Clover
Third year —Corn
Fourth year—Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year—Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute barley or rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover, or it may include alfalfa used as a biennial. The mixing of alfalfa with clover seed for a legume crop is a recommendable practice. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experimental Fields on Soil Types Similar to those Occurring in Whiteside County)

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system. Some modifications have been introduced in recent years as will be explained in the descriptions of the respective fields.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grain to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated (aP = acid phosphate, bP = bonemeal, rP = rock phosphate, sP = slag phosphate)
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
Le = Legume used as green manure
Cv = Cover crop
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed
| = Heavy vertical rule, indicating the beginning of complete treatment
|| = Double vertical rule, indicating a radical change in the cropping system

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

THE MT. MORRIS FIELD

The Mt. Morris experiment field was established in 1910 at Mt. Morris in Ogle county. The soil represents fairly well the type Light Brown Silt Loam, altho the plots are not altogether uniform in this respect. The plots considered here comprize four series under a rotation of corn, oats, clover, and wheat, with soil treatments as indicated in the accompanying table. The application of straw to the residues plots has been discontinued in these later years. In 1922 the application of limestone, and in 1923 the application of rock phosphate, were indefinitely suspended in order in observe the residual effect of these materials.

FIG. 3.—CORN ON THE MT. MORRIS FIELD

The two pictures represent the extremes in soil treatment on this field. Where the untreated land has produced as a fourteen-year average 44.6 bushels of corn an acre, the land under the residues, limestone, phosphate, potash treatment has yielded 67.2 bushels. The most profitable treatment on this field, however, has been that of residues and limestone, which has produced 62.2 bushels an acre.

TABLE 7.—MT. MORRIS FIELD: SERIES 100, 200, 300, 400, SUMMARY OF CROP YIELDS

Average Annual Yields 1913-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *14 crops*	Oats *14 crops*	Wheat *12 crops*	Clover[1] *10 crops*	Soybeans *2 crops*
1	0	45.3	58.5	23.3	(1.96)	(1.56)
2	M	59.5	67.4	28.1	(2.53)	(1.70)
3	ML	64.4	70.5	34.4	(2.97)	(1.80)
4	MLP	64.3	71.5	35.9	(2.92)	(1.92)
5	0	44.6	54.9	23.5	(1.61)	13.5
6	R	51.2	59.4	25.8	(1.77)	16.0
7	RL	62.2	68.8	32.7	(2.24)	18.9
8	RLP	65.6	70.2	36.2	(2.23)	20.7
9	RLPK	67.2	70.4	36.3	(2.24)	20.0
10	0	43.6	52.4	24.6	(1.79)	(1.68)
	Crop Increases					
	M over 0	14.2	8.9	4.8	(.57)	(.14)
	R over 0	6.6	4.5	2.3	(.16)	2.5
	ML over M	4.9	3.1	6.3	(.44)	(.10)
	RL over R	11.0	9.4	6.9	(.47)	2.9
	MLP over ML	− .1	1.0	1.5	−(.05)	(.12)
	RLP over RL	3.4	1.4	3.5	−(.01)	1.8
	RLPK over RLP	1.6	.2	.1	(.01)	− .7

[1]Some clover seed evaluated as hay.

A summary of the results of the work is given in Table 7, in the form of the average annual crop yields for the years since the complete soil treatments have been in effect.

In looking over these results, one may observe first the beneficial effect of farm manure (M). The annual crop increases due to the use of manure alone amount to over 14 bushels an acre for corn, nearly 9 bushels of oats, almost 5 bushels of wheat, and about ½ ton of clover. Organic manure furnished by "residues" (R) has likewise proved beneficial to all crops, but not in the same degree as stable manure.

Limestone (L) in addition to organic manures has been used with good effect, the improvement being especially marked in the residues system.

Rock phosphate (P) has produced no significant effect applied with manure and limestone. In the corresponding residues system the increases in yield obtained from rock phosphate are somewhat larger, but they have not been sufficient to cover the cost of the phosphate applied.

Potassium (K), in the combination used in these experiments, has produced no results of significance.

THE DIXON FIELD

A summary of the results of the Dixon experiment field are presented here, inasmuch as the soil of this field is similar to some of that found in Whiteside county. This field includes about 21 acres and is laid out into two general systems of plots, a major and a minor system. The results from the major system will be considered here.

The rotation practiced has been wheat, corn, oats, and clover. The treatment of the plots and management of the crops were, for the most part, maintained up to 1922 according to the general plan described above on page 47. The more important modification of the plan has been the discontinuance, within the last few years, of the applications of limestone, phosphate, and straw residues.

Table 8 gives a summary of the results in terms of the average annual crop yields obtained since the plots have been under complete treatment.

In considering these results, the most striking feature to be observed is the outstanding effect of farm manure (M). The average annual increase due to the use of manure alone has amounted to nearly 20 bushels of corn an acre, more than 12 bushels of oats, nearly 7 bushels of wheat, ⅔ of a ton of clover, and ⅓ of a ton of soybean hay.

Organic manure (R) in the form of crop residues has also produced increases in yields altho not to the extent of those produced by animal manure.

Limestone (L) in addition to organic manures has, with a single exception, effected more or less improvement, probably sufficient to cover the expense of application.

Rock phosphate (P), as usual, shows up to best advantage when used with residues on the wheat crop. The effect on other crops, however, has been such that the increases in yield are not sufficient to cover the cost of the application under existing market conditions.

TABLE 8.—DIXON FIELD: SERIES 100, 200, 300, 400, SUMMARY OF CROP YIELDS
Average Annual Yields 1912-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *15 crops*	Oats *14 crops*	Wheat *11 crops*	Barley *1 crop*	Clover[1] *9 crops*	Soybeans *4 crops*
1	0	36.3	49.0	20.3	43.3	(1.73)	(1.46)
2	M	55.6	61.7	26.9	46.4	(2.44)	(1.78)
3	ML	59.7	65.5	31.0	55.2	(2.70)	(1.92)
4	MLP	62.3	67.3	34.2	58.3	(2.82)	(1.97)
5	0	42.6	54.4	21.7	49.5	(1.35)	11.8
6	R	50.5	58.7	24.8	53.8	(1.47)	13.5
7	RL	56.4	62.6	28.0	54.5	(1.77)	13.3
8	RLP	57.7	65.1	32.9	59.0	(2.04)	13.3
9	RLPK	61.1	64.6	33.7	56.9	(2.18)	14.0
10	0	41.3	52.0	20.0	45.4	(1.89)	(1.45)
	Crop Increases						
	M over 0	19.3	12.7	6.6	3.1	(.71)	(.32)
	R over 0	7.9	4.3	3.1	4.3	(.12)	1.7
	ML over M	4.1	3.8	4.1	8.8	(.26)	(.14)
	RL over R	5.9	3.9	3.2	.7	(.30)	− .2
	MLP over ML	2.6	1.8	3.2	3.1	(.12)	(.05)
	RLP over RL	1.3	2.5	4.9	4.5	(.27)	0.0
	RLPK over RLP	3.4	− .5	.8	− 2.1	(.14)	.7

[1] Including some seed crops evaluated in this summary as hay.

Altho potassium (K) has produced an average increase of 3.4 bushels an acre in corn, the effects on other crops are such as to render its use unprofitable in growing these common field crops.

THE UNION GROVE FIELD

The University maintained a soil experiment field in Whiteside county for about seventeen years. The field lay about 1½ miles northwest of Union Grove on land represented on the soil map as Brown Silt Loam Over Gravel. The soil was described at the time of the establishment of the field as a "brown silt loam over sandy loess"; the experimental results, however, will doubtless apply also to other soil types in the region possessing somewhat similar characteristics.

The field was laid out into five series of plots. On these series two different systems of cropping were carried on, designated in the records as the major and the minor rotations.

The Major Rotation

The major rotation consisted of corn, corn, oats or barley, and clover on Series 100 and 200. The soil treatments were similar to those described on page 47 except that potassium was supplied in 100 pounds of potassium sulfate an acre a year, and commercial nitrogen in the form of dried blood was supplied annually to Plot 19 at the rate of 200 pounds an acre. In 1916 this plot was divided, dried blood being applied to the east half and gluten meal at the annual acre rate of 376 pounds to the west half.

TABLE 9.—UNION GROVE FIELD: SERIES 100, 200

Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1907 Corn[1]	1908 Oats[2]	1909 Clover[2]	1910 Corn[4]	1911 Corn[4]	1912 Oats	1913 Clover	1914 Corn	1915 Corn	1916 Barley	1917 Soy-beans	1918 Corn	1919 Corn	1920 Barley	1921 Clover	1922 Corn	1923 Corn
101	L	31.7	35.8	(2.49)	30.1	40.9	52.0	(4.00)	40.8	16.9	44.7	(1.55)	36.1	31.1	19.3	(2.11)	40.3	42.0
102	RL	36.4	43.0	.. [3] ..	43.2	58.1	63.6	.75	64.7	32.3	53.9	17.7	64.8	63.8	25.0	(2.92)	58.2	39.1
103	ML	35.1	40.0	(2.79)	43.0	56.8	61.3	(4.38)	67.2	42.7	60.2	(2.41)	70.6	73.9	26.7	(3.07)	77.9	57.8
104	CvML	39.4	49.5	(2.85)	52.7	52.4	60.5	(3.95)	63.8	35.8	55.9	(2.38)	71.9	71.2	30.4	(3.29)	58.2	41.8
105	L	33.9	45.5	(2.85)	29.0	38.6	37.0	(3.64)	46.8	15.3	41.7	(1.50)	22.6	27.1	20.1	(2.17)	32.8	30.5
106	LP	33.8	43.8	(2.83)	30.4	46.4	50.9	(3.77)	43.8	19.9	54.9	(1.30)	38.0	31.3	20.8	(2.41)	34.8	36.5
107	RLP	45.1	52.2	.. [3] ..	39.3	68.3	70.8	1.08	71.5	37.9	62.2	14.8	67.7	61.4	28.5	(2.97)	51.4	43.6
108	MLP	39.4	49.8	(2.70)	45.7	61.3	48.6	(3.38)	74.3	38.7	61.5	(2.20)	70.2	63.1	31.2	(3.22)	83.2	53.7
109	CvMLP	40.4	49.4	(2.85)	41.0	59.8	60.0	(3.88)	72.1	45.6	57.7	(2.30)	71.3	63.6	27.5	(3.56)	87.3	57.6
110	L	36.9	46.9	(2.83)	33.0	48.9	50.8	(4.44)	53.4	18.7	47.7	(1.62)	35.4	33.3	22.5	(2.57)	37.9	38.1
111	LPK	40.9	49.5	(3.37)	44.0	66.3	57.7	(4.60)	74.0	38.2	60.9	(1.60)	68.4	64.9	28.1	(3.72)	74.2	56.0
112	RLPK	54.4	53.9	.. [3] ..	54.8	77.2	69.8	.67	79.6	40.7	64.3	16.8	76.5	70.7	30.0	(4.06)	89.2	56.3
113	MLPK	50.6	53.4	(3.01)	51.8	70.4	54.8	(3.29)	72.0	42.1	56.7	(2.25)	72.0	82.3	37.6	(4.00)	90.2	64.8
114	CvMLPK	52.0	46.7	(2.79)	47.7	68.8	59.2	(3.17)	73.1	36.3	61.9	(2.18)	74.0	72.9	29.2	(3.93)	89.0	65.4
115	L	43.3	43.3	(2.09)	30.0	39.0	46.4	1.17	51.3	16.4	45.0	14.2	25.1	25.9	19.2	(1.61)	36.8	37.2
116	R	42.3	40.3	.. [3] ..	42.0	59.1	59.4	1.50	63.4	26.4	54.5	15.9	51.6	52.1	24.5	(1.74)	42.3	42.0
117	RP	42.9	42.8	.. [3] ..	42.6	60.3	67.2	1.92	70.3	38.2	58.6	12.7	56.9	56.1	25.0	(2.24)	47.0	43.0
118	RPK	47.3	44.1	.. [3] ..	54.2	72.1	69.7	1.58	77.9	42.9	58.8	16.4	64.5	59.0	31.8	(3.39)	76.7	47.6
119	RLNPK	50.6	53.3	.. [3] ..	56.7	74.2	70.5	.83	76.2	41.2	57.6	17.1	75.4	69.1	31.4	(3.65)	92.9	67.8
120	0	33.1	35.2	(2.12)	28.6	35.6	54.1	(2.97)	44.7	14.5	45.5	(1.08)	29.3	33.4	12.3	(0.00)	38.8	33.5

[1]Nitrogen, phosphorus, and potassium only. [2]No lime or manure. [3]Growth plowed down. [4]No lime.

TABLE 9.—*Concluded*

Bushels or (tons) per acre

Plot No.	Soil treatment applied	1907 Clover[1]	1908 Corn[2]	1909 Corn[3]	1910 Oats[3]	1911 Soybeans[3]	1912 Corn	1913 Corn	1914 Oats	1915 Clover	1916 Corn	1917 Corn	1918 Barley	1919 Clover	1920 Corn	1921 Corn	1922 Barley	1923 Soybeans
201	L	.....	63.6	57.6	68.3	23.1	54.5	35.9	51.6	(3.12)	36.8	33.0	39.0	(4.05)	42.2	43.6	27.0	4.8
202	RL	.....	56.6	61.5	74.2	25.3	73.4	45.1	49.8	1.42	50.4	43.9	52.8	(2.45)	63.2	61.7	36.2	8.2
203	ML	.....	61.2	60.6	67.8	24.1	84.9	51.5	48.3	(3.34)	50.0	50.7	55.2	(4.31)	63.3	71.9	47.3	7.0
204	CvML	.....	56.1	59.9	72.3	25.0	85.5	48.9	45.3	(2.98)	52.1	50.9	55.2	(4.51)	71.3	74.9	46.3	7.2
205	L	.....	58.8	61.6	64.5	23.0	55.7	34.7	47.2	(2.59)	34.9	32.1	38.8	(4.10)	49.5	40.1	29.8	4.8
206	LP	.....	54.4	60.0	65.5	23.8	66.5	34.7	51.7	(3.00)	35.2	38.4	50.0	(4.13)	45.3	41.3	32.5	3.7
207	RLP	.....	55.9	56.1	81.3	25.2	76.4	46.0	59.8	1.25	49.3	48.8	59.2	(2.55)	59.6	59.0	39.4	6.9
208	MLP	.....	57.5	61.6	75.0	24.8	88.0	50.4	45.6	(3.65)	49.0	54.2	54.8	(3.83)	62.2	77.6	46.0	9.5
209	CvMLP	.....	55.9	61.0	80.0	24.9	85.6	51.4	50.2	(3.42)	51.6	54.2	53.4	(3.34)	67.1	79.9	49.4	9.8
210	L	.....	55.1	51.2	57.7	22.8	58.3	30.7	50.3	(2.68)	34.1	33.4	37.9	(3.57)	45.8	44.4	26.1	5.9
211	LPK	.....	55.1	52.2	55.0	23.0	69.9	44.1	50.3	(3.28)	47.1	51.3	39.5	(3.33)	63.2	78.1	38.2	10.2
212	RLPK	.....	56.5	49.1	65.3	23.5	77.7	49.4	61.7	.92	55.1	64.6	55.0	(2.00)	70.2	70.1	41.7	10.0
213	MLPK	.....	51.8	45.9	58.8	22.8	88.0	50.6	55.8	(3.05)	53.5	60.2	51.6	(3.72)	67.5	69.6	54.8	13.4
214	CvMLPK	.....	39.0	41.2	60.8	22.8	85.5	50.8	50.6	(3.04)	52.6	57.9	50.7	(3.46)	71.2	71.5	49.9	12.6
215	L	.....	30.2	33.6	55.0	21.8	20.1	19.1	48.9	1.58	28.1	22.7	34.2	(3.32)	35.3	35.7	27.9	2.3
216	R	.....	31.2	36.6	60.6	23.8	54.1	28.8	57.0	1.33	39.2	35.8	54.7	(2.21)	43.4	51.7	32.9	7.2
217	RP	.....	32.2	37.2	67.5	22.9	68.5	29.3	65.8	.92	44.5	41.3	47.2	(2.21)	46.8	49.5	37.7	6.5
218	RPK	.....	49.5	40.2	66.4	24.5	77.4	41.1	63.3	.92	48.7	50.5	49.2	(2.42)	61.3	63.2	42.8	9.9
219	RLNPK	.....	51.1	47.6	73.0	24.5	81.7	47.2	62.2	1.50	54.3	57.3	58.9	(2.52)	59.8	66.3	47.7	12.0
220	0	.....	30.4	32.2	49.5	21.4	27.2	19.5	55.0	(1.69)	23.5	23.2	39.4	(3.26)	36.9	33.4	25.2	5.4

[1]No treatment; all plots harvested together. [2]Nitrogen, phosphorus, and potassium only. [3]No lime or manure.

TABLE 10.—UNION GROVE FIELD: SUMMARY OF GRAIN YIELDS

Average Annual Yields 1912-1923—Bushels or (tons) per acre [1]

Serial plot No.	Soil treatment applied	Corn *12 crops*	Oats *2 crops*	Barley *4 crops*
1	L	37.8	51.8	32.5
2	RL	55.0	56.7	42.0
3	ML	63.5	54.8	47.3
4	CvML	60.5	52.9	47.0
5	L	35.2	42.1	32.6
6	LP	38.8	51.3	39.6
7	RLP	56.0	65.3	47.3
8	MLP	63.7	47.1	48.4
9	CvMLP	65.6	55.1	47.0
10	L	38.6	50.6	33.6
11	LPK	60.8	54.0	41.7
12	RLPK	66.7	65.8	47.8
13	MLPK	67.7	55.3	50.2
14	CvMLPK	66.7	54.9	47.9
15	L	29.5	47.7	31.6
16	R	44.2	58.2	41.7
17	RP	49.3	66.5	42.1
18	RPK	59.2	66.5	45.7
19	NRLPK	65.8	66.3	48.9
20	0	29.6	54.6	30.6
	Crop Increases			
Limestone				
L	over 0	5.7	−6.5	2.0
LR	over R	10.8	−1.5	.3
LRP	over RP	6.7	−1.2	5.2
LRPK	over RPK	7.5	− .7	2.1
Residues				
R	over 0	14.6	3.6	11.1
RL	over L	19.7	8.6	9.4
RLP	over LP	17.2	14.0	7.7
RLPK	over LPK	5.9	11.8	6.1
Manure				
ML	over L	28.2	6.7	14.7
MLP	over LP	24.9	−4.2	8.8
MLPK	over LPK	6.9	1.3	8.5
Phosphorus				
PL	over L	3.5	3.2	7.0
PR	over R	5.1	8.3	.4
PLR	over LR	1.0	8.6	5.3
PLM	over LM	.2	−7.7	1.1
PCvLM	over CvLM	5.1	2.2	0.0
Potassium				
KLP	over LP	22.0	2.7	2.1
KRP	over RP	9.9	0.0	3.6
KLRP	over LRP	10.7	.5	.5
KLMP	over LMP	4.0	8.2	1.8
KCvLMP	over CvLMP	1.1	− .2	.9

In 1919 it was planned to harvest the first crop of clover as hay on all plots and the second crop as seed on the residues plots. The limestone applications were discontinued in 1920 after the plots had received a total of 14,000 to 16,000

pounds an acre. Beginning in 1921 all clover was harvested as hay and the return of the straws discontinued. In 1922 the application of manure was discontinued on Plot 4, as was also the application of phosphate to Plots 9 and 14.

The results from this field are presented in detail in Table 9, which gives the yields produced for the various soil treatments for each year thruout the entire course of the experiments. Table 10 gives a summary of the grain yields during the period after the complete treatments had been begun, the upper part of the table showing the average annual yields secured and the lower part certain comparisons of the various treatment combinations.

In considering the results it is to be observed that this land is not altogether uniform in productiveness, as is evidenced by the rather wide discrepancies appearing in the replicated lime plots; and therefore considerable allowance must be made in drawing conclusions based upon minor differences. However, some of the comparisons are measured by differences so large and so consistent as to carry significance.

Limestone.—For studying the effect of limestone, the results for the four plots receiving limestone alone, Nos. 1, 5, 10, and 15, are averaged together. The results were rather erratic if the negative response shown by the two oats crops be considered significant. However, limestone appears on the whole to have returned some profit, especially where used in combination with residues, or with residues and minerals.

Residues.—The beneficial effect of crop residues stands out prominently, large increases in yield appearing without exception wherever residues were applied, whether used alone or in combination with other fertilizer materials.

Manure.—The high fertility value of animal manure is likewise demonstrated. Naturally, the greatest effect is seen where manure is used with limestone alone, for the manure itself contains a certain amount of both phosphorus and potassium, so that when these substances are applied as supplementary fertilizing materials, the full value of the manure cannot come into play.

Phosphorus.—Phosphorus in the form of rock phosphate appears to have been somewhat beneficial, but in no combination used were the crop increases sufficient to cover the expense of its application.

Potassium.—Used in certain combinations, potassium sulfate produced very marked effects on the corn crop, resulting in large increases in yield. The most remarkable increase of this kind was on the plot where potassium sulfate was added to limestone and rock phosphate. Here the average increase in corn yield amounted to 22 bushels an acre. In those combinations in which farm manure was a constituent, no such beneficial effect appears, probably because of the fact that considerable potassium is contained in animal manure.

The Minor Rotation

The minor series, numbered 300, 400, and 500, were plotted in 1913 and discontinued in 1919. A nine-year rotation of potatoes and alfalfa was established, the potatoes growing three years on a given series and the alfalfa six years. There were only four plots in each series and these were similar to certain

TABLE 11.—UNION GROVE FIELD: SERIES 300, 400, 500
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1913 Potatoes	1914 Potatoes	1915 Potatoes	1916 Alfalfa	1917 Alfalfa[3]	1918 Alfalfa seeding	1919 Alfalfa
301	0	46.8	59.2	66.8	(1.60)	....	....	(.60)
302	M	112.2	142.3	265.0	(5.35)	....	....	(1.37)
303	ML	83.7	113.6	237.4	(5.54)	....	....	(1.42)
304	MLP	91.7	117.5	251.8	(5.67)	....	....	(2.11)
		Alfalfa[1,2]	Alfalfa[1]	Alfalfa[1]	Potatoes	Potatoes	Potatoes	Alfalfa
401	0	....	(3.30)	(4.74)	68.4	54.6	18.7	(1.22)
402	M	....	(3.55)	(4.72)	143.5	149.2	107.8	(2.07)
403	ML	....	(3.81)	(4.87)	123.3	152.5	97.9	(2.22)
404	MLP	....	(3.58)	(5.00)	115.2	134.2	105.6	(2.37)
		Alfalfa[1,2]	Alfalfa[1]	Alfalfa[1]	Alfalfa[1]	Alfalfa[1,3]	Soybeans[1]	Potatoes
501	0	....	(3.03)	(4.47)	(4.12)	....	(3.00)	25.2
502	M	....	(3.32)	(4.50)	(4.12)	....	(3.22)	42.3
503	ML	....	(4.40)	(5.24)	(4.99)	....	(3.33)	34.5
504	MLP	....	(5.34)	(5.57)	(5.88)	....	(4.40)	35.2

[1]No manure. [2]All plots harvested together; the yield was 5.57 tons per acre. [3]Killed by a heavy freeze in April.

of those in the larger series except that manure was applied at the rate of 15 tons an acre for each potato crop.

The yields for all crops harvested in this rotation are recorded in Table 11. Because of so much incompleteness in carrying out the full treatment program, no tabulated summary is presented, but certain observations of interest can be made by a glance at the figures as they stand. The beneficial effect of farm manure on the potatoes is apparent. Rather strangely, the best yields were made on the plots treated with manure alone. The limestone seems to have had a

FIG. 4.—ALFALFA ON A PORTION OF THE UNION GROVE EXPERIMENT FIELD

In some seasons excellent yields of alfalfa were produced on this field without soil treatment, as seen in this picture. As an average for five seasons, however, where untreated land produced 3.9 tons of hay an acre, land receiving limestone yielded 4.7 tons. Where both limestone and rock phosphate had been applied, the yield increased to 5.1 tons an acre.

detrimental effect and apparently the rock phosphate was unable to overcome this effect.

It may be noted that some excellent yields of alfalfa were produced on this land, especially on the treated plots, altho an unfortunate freeze occurred in 1917 which killed the stand, thus cutting severely the profits from this crop.

THE VIENNA FIELD

Whiteside county, as indicated in the descriptions of certain of its soil types, includes considerable land that is subject to destruction thru erosion or washing. Yellow Silt Loam, which occupies over 38 square miles in the county, is particularly susceptible to this kind of damage. Operators of land in Whiteside county will therefore be interested in experiments conducted on the Vienna field, in Johnson county, to test out different methods of reclaiming badly gullied land and preventing further erosion.

The Vienna field is representative of the sloping, erodible land so common in the extreme southern part of the state. When the experiments were started the whole field, with the exception of about three acres, had been abandoned because so much of the surface soil had washed away, and there were so many gullies that further cultivation was unprofitable. For the purpose of the experiments the field was divided into different sections (see Table 12.) These were not entirely uniform; some parts were much more washed than others, and portions of the lower-lying land had been affected by soil material washed down from above. The higher land had a very low producing capacity; on many spots little or nothing would grow.

TABLE 12.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

Section A included the steepest part of the field and contained many gullies. The land was built up into terraces at vertical intervals of 5 feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

Section B was used to test the so-called embankment method. Ridges were plowed up which were sufficiently high so that when there were heavy falls of rain the water would break over and run in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about 8 loads of manure an acre were turned under each year for the corn crop.

Section D was washed to about the same extent as Section C. It was farmed in the most convenient way, without any special effort to prevent washing.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except the one designated as D, which included but three plots.

Careful records were kept for nine years. The results, summarized in Table 12, indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels on the check series (D). Wheat yielded 11.1 bushels on the protected series, in comparison with 4.6 bushels on the check, and clover yielded ⅘ of a ton on the protected series and but ⅕ of a ton on the check.

Figs. 5 and 6 serve further to indicate what may be done with this type of soil even after it has become badly washed and gullied.

FIG. 5.—PROPER SOIL AND CROPPING METHODS WOULD HAVE PREVENTED THIS CONDITION

This abandoned hillside is just over the fence from the field shown in Fig. 6. Yellow Silt Loam is particularly susceptible to this kind of damage.

FIG. 6.—CORN GROWING ON AN IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD

This land had formerly been badly eroded. It was reclaimed by proper soil treatment and cropping. Compare with Fig. 5.

THE OQUAWKA FIELD

Since there are considerable areas of Dune Sand, Terrace, in Whiteside county, experiments on that type conducted by the University in Henderson county, near the Mississippi river, will be of interest. The field was established in 1913. It is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted. Table 13

TABLE 13.—OQUAWKA FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1915-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *12 crops*	Soybeans *12 crops*[1]	Wheat *12 crops*	Sweet clover[2] *8 crops*	Rye *10 crops*	Alfalfa *9 crops*
1	0	20.2	(.99)	8.7	0.0	12.1	(.42)
2	M	25.3	(1.19)	12.0	0.0	13.7	(.92)
3	ML	33.4	(1.61)	16.1	1.03	24.7	(2.37)
4	MLP	33.9	(1.56)	16.4	1.05	23.4	(2.45)
5	0	19.7	(.77)	10.7	0.0	12.7	(.40)
6	R	21.2	(.82)	12.2	0.0	12.9	(.45)
7	RL	37.2	(1.17)	15.1	1.41	24.0	(2.11)
8	RLP	37.0	(1.25)	15.6	1.28	24.1	(2.10)
9	RLPK	39.2	(1.20)	14.9	1.49	26.0	(2.17)
10	0	18.6	(.71)	9.6	0.0	10.3	(.29)
	Crop Increases						
	M over 0	5.1	(.20)	3.3	0.0	1.6	(.50)
	R over 0	1.5	(.05)	1.5	0.0	.2	(.05)
	ML over M	8.1	(.42)	4.1	1.03	11.0	(1.45)
	RL over R	16.0	(.35)	2.9	1.41	11.1	(1.66)
	MLP over ML	.5	(− .05)	.3	.02	− 1.3	(.08)
	RLP over RL	− .2	(.08)	.5	− .13	.1	(− .01)
	RLPK over RLP	2.2	(− .05)	− .07	.21	1.9	(.07)

[1] Eleven regular crops, together with the extra crop described in the following footnote, averaged as 11 crops since the extra crop was a substitute for the red clover which killed out. Several crops which were harvested as seed are evaluated in this summary as hay.

[2] Some hay evaluated as seed. In 1918 the sweet clover was killed by early cutting for a hay crop. Soybeans were seeded in July and the ensuing crop is included in the soybean average.

indicates the kinds of treatment applied; the amounts of the materials used were in accord with the standard practice, as explained on page 47.

Limestone (L), it will be noted, has had a remarkably beneficial action on this sand soil. Where it has been used in conjunction with crop residues, the yield of corn has been practically doubled. It has also produced good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite indifferent to treatment with rock phosphate (P). The analyses show, however, that the stock of phosphorus in this type of soil is not large; and as time goes on and the supply diminishes under the production of good-sized crops, the application of this element may become profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

Altho the results show an increase of about 2 bushels of corn from the use of potassium salts (K), with ordinary prices this would not be a profitable treatment. The slight increases from the use of potassium appearing in the other crops are scarcely significant.

A significant fact which the above summary does not bring out is that improvement in crop yields under favorable treatment has been progressive, as evidenced by a very marked upward trend in production after the first few years. The yield of corn, for example, under the limestone-residues (RL) treatment

Catch crop, crop residues
Yield 27 bushels

Catch crop, crop residues, limestone
Yield 43 bushels

FIG. 7.—CORN ON THE OQUAWKA FIELD, DUNE SAND, TERRACE

These pictures show the effect on the corn crop of the use of limestone in the residues system. Following the application of limestone, sweet clover makes a thrifty growth, which in turn benefits the corn and other crops in the rotation. As the average of the last rotation the plot at the left has produced 27 bushels of corn an acre, while that at the right has given a yield of 43 bushels.

has been 37.2 bushels an acre as an average for the 12 crops since full treatment started, but if we take an average of the last five crops, the yield rises to 42.9 bushels. Likewise the wheat yield under this same treatment for the eleven-year average is 15.1 bushels, but the average for the last five years is 22.3 bushels.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover grow better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

THE MANITO FIELD

The Manito experiment field, in Mason county, which was in operation from 1902 to 1905, gives some interesting results of the effects of soil treatment on Deep Peat.

The field consisted of ten plots which received the treatments indicated in Table 14. Where potassium was applied, the yield was three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were used, slightly greater yields were obtained

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 8.—ALFALFA ON THE OQUAWKA FIELD

These pictures show the possibility of improving this unproductive sandy land of the Oquawka field. Both plots were seeded alike to alfalfa. Where manure alone was applied, the crop was a total failure, but where limestone in addition to manure was applied, nearly 4½ tons of alfalfa hay was obtained as the season's yield.

with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. However, either material furnished more potassium than was required by the crops produced.

TABLE 14.—MANITO FIELD: DEEP PEAT

Annual Crop Yields—Bushels per Acre

Plot No.	Soil treatment 1902	Corn 1902	Corn 1903	Soil treatment 1904	Corn 1904	Corn 1905
1	None	10.9	8.1	None	17.0	12.0
2	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1
3	Kainit, 600 lbs.	30.4	32.4	Limestone, 4000 lbs., kainit, 1200 lbs.	49.6	47.3
4	Kainit, 600 lbs., acidulated bone, 350 lbs.	30.3	33.3	Kainit, 1200 lbs., steamed bone, 395 lbs.	53.5	47.6
5	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs.	44.5	47.3
8	Kainit, 600 lbs.	36.8	37.7	Kainit, 600 lbs.	44.0	46.0
9	Kainit, 300 lbs.	26.4	25.1	Kainit, 300 lbs.	41.5	32.9
10	None	[1]	14.9	None	26.0	13.6

[1]Yield not recorded for 1902.

The use of 700 pounds of sodium chlorid (common salt) yielded no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons of ground limestone per acre produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the total yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) appear to be insufficient.

THE TAMPICO FIELD

An experiment field representing a large area of the unproductive peaty land in Whiteside and neighboring counties was temporarily conducted by the University for three years beginning in 1902. This field was located about 5 miles northeast of Tampico on the soil type mapped as Peaty Loam. The soil is described as consisting of "black peaty material, rich in organic matter to a

FIG. 9.—CORN ON THE TAMPICO FIELD, PEATY LOAM

The application of potassium in some form is an absolute necessity in order to produce corn on this black peaty soil. On the plot at the left the crop was a failure, altho lime, nitrogen, and phosphorus had been applied. The plot at the right, receiving lime, nitrogen, and potassium, produced 58.7 bushels of corn an acre.

depth of 16 inches. Between 16 and 30 inches, the material is lighter in color and quite sandy, with little organic matter. The subsoil below 30 inches is almost pure coarse sand."

This field consisted of but a single series of 10 plots. The plan of treatment is indicated in Table 15. Nitrogen was applied in 800 pounds of dried blood an acre a year and phosphorus in 200 pounds of bone meal. The potassium was furnished by 200 pounds an acre of potassium chlorid applied in 1902 and by the same quantity of potassium sulfate applied in each of the two years following. Slaked lime was applied at the rate of 450 pounds an acre in 1902. Corn was the only crop grown during the three-year test.

The results in terms of annual corn yields are recorded in Table 15. According to notations in the records the plots were not altogether uniform with respect to topography. Plots 9 and 10, lying a little higher than the others, were more favorably located for the excessively wet seasons of 1902 and 1903, thus causing

TABLE 15.—TAMPICO FIELD: ANNUAL CROP YIELDS

Bushels per acre

Plot No.	Soil treatment applied	1902 Corn	1903 Corn	1904 Corn
101	None	0.0	0.0	0.0
102	Lime (and potassium after 2 years)	0.0	0.0	26.9[1]
103	Lime, nitrogen	0.0	0.0	0.0
104	Lime, bone meal	0.0	0.0	0.0
105	Lime, potassium	34.1	45.4	45.2
106	Lime, nitrogen, bone meal	0.0	0.0	0.0
107	Lime, nitrogen, potassium	37.6	58.7	44.1
108	Lime, bone meal, potassium	35.3	46.8	43.0
109	Lime, nitrogen, bone meal, potassium	56.5	65.9	44.0
110	Nitrogen, potassium, bone meal	49.4	58.6	35.6[2]

[1] 125 pounds potassium sulfate per acre was applied to Plot 102 in 1904. [2] No potassium was applied to Plot 110 in 1904.

the nitrogen and phosphorus treatments on these plots to appear at an unfair advantage. In 1904, with a more nearly normal rainfall, this undue advantage disappeared and these plots yielded no more than the corresponding plot treated with potassium (Plot 105). This lack of response from both the nitrogen and the phosphorus treatments is not surprising if the composition of Peaty Loam type be taken into consideration; by reference to the tables of plant-food content (page 11 to 13) it will be observed that this type of soil is extraordinarily high in nitrogen and also very rich in phosphorus.

The lime was without effect but, as a matter of fact, this land does not need lime, as evidenced by the high calcium content shown in the analyses of samples of this soil type.

The outstanding feature of these results is shown in the response to potassium fertilization. Every plot from which potassium was omitted was invariably a total crop failure; while every plot treated with a potassium salt produced each year a fair yield of corn.

These experimental results on the Tampico field are borne out in the practical experience of farmers in the vicinity, and the conclusion is that some potassium-bearing mineral is essential in any scheme to make this land productive.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1925
33 Saline, 1926
34 Marion, 1926
35 Will, 1926
36 Woodford, 1927
37 Lee, 1927
38 Ogle, 1927
39 Logan, 1927
40 Whiteside, 1928

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

JAN 11

SOIL REPORT NO. 41

HENRY COUNTY SOILS

BY R. S. SMITH, E. E. DeTURK, F. C. BAUER, AND L. H. SMITH

URBANA, ILLINOIS, OCTOBER, 1928

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due Mr. O. I. Ellis, who, as leader of the field party, was in direct charge of the mapping.

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HENRY COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

PHYSICAL GEOGRAPHY OF THE COUNTY

Henry county is situated in the northwestern part of Illinois, a little above the 41st parallel of latitude. Rock river forms its northwestern border for about twenty miles. It is 815 square miles in area, and about a third of it lies in the Green river basin.

The Weather Bureau records taken at Galva for the 31-year period 1895 to 1926 are used as representing the climatic conditions of the county. The greatest range in temperature for any one year during this period was 126 degrees in 1899 and again in 1916. The lowest temperature was 28° below zero in 1905, the highest 108° in 1901. The average date of the last killing frost in the spring is April 28; the earliest in the fall, October 13. The average length of the growing season is therefore about 168 days.

The average annual rainfall for the period 1895 to 1926 was 33.11 inches. The rainfall by months was as follows: January, 1.65 inches; February, 1.43; March, 2.71; April, 2.85; May, 4.11; June, 3.71; July, 3.84; August, 3.61; September, 3.89; October, 2.11; November, 1.79; December, 1.42.

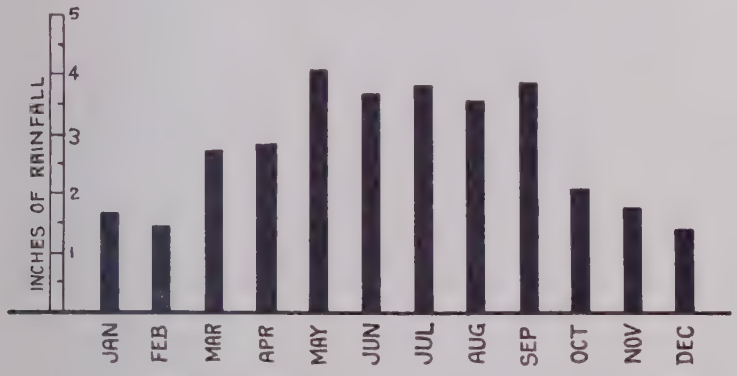


Fig. 1.—Monthly Distribution of Rainfall in Henry County

The distribution of the rainfall thruout the year is on the whole favorable for the production of the crops commonly grown in Henry county.

AGRICULTURAL PRODUCTION

The diversified soil and topographic conditions in Henry county have resulted in diversified farming, with stock raising taking an important place in the agriculture of the county.

In 1920, according to the Fourteenth Census, there were 3,161 farms in Henry county, a decrease of about 5 percent in ten years. The following figures show the acreage and production of the principal crops grown in the county for the year 1919:

[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	146,430	6,587,017 bu.	44.9 bu.
Oats	75,295	2,449,223 bu.	32.5 bu.
Wheat	22,423	424,981 bu.	18.9 bu.
Timothy	10,763	14,926 tons	1.38 tons
Timothy and clover mixed	27,301	41,966 tons	1.54 tons
Clover	9,157	13,933 tons	1.52 tons
Alfalfa	1,440	3,960 tons	2.75 tons
Silage crops	6,887	59,037 tons	8.57 tons
Corn for forage	3,624	8,223 tons	2.27 tons

The total value of all crops for 1919 was estimated at $15,746,000. No figures are available showing the acreage used for pasture but the hilly and eroded portions are very generally devoted to this use.

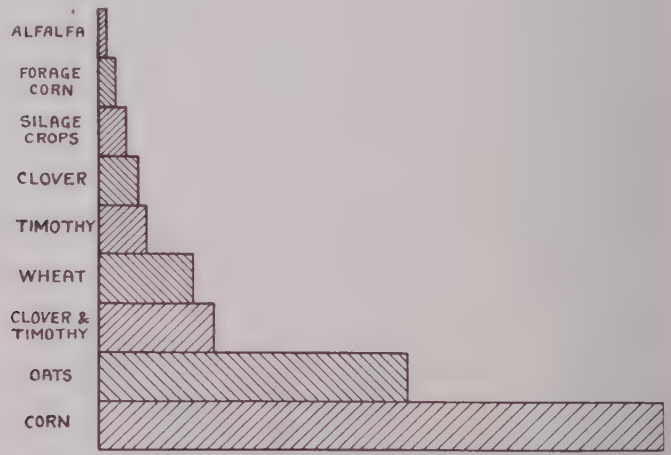


FIG. 2.—RELATIVE ACREAGE OF FIELD CROPS IN HENRY COUNTY

The diagram brings out the preponderance of land devoted to corn and oats. Legume crops might well occupy a larger proportion of the cultivated acreage. (From 1920 Census.)

The importance of the livestock industry in this county, particularly beef cattle and hogs, is shown by the following figures taken from this same Census:

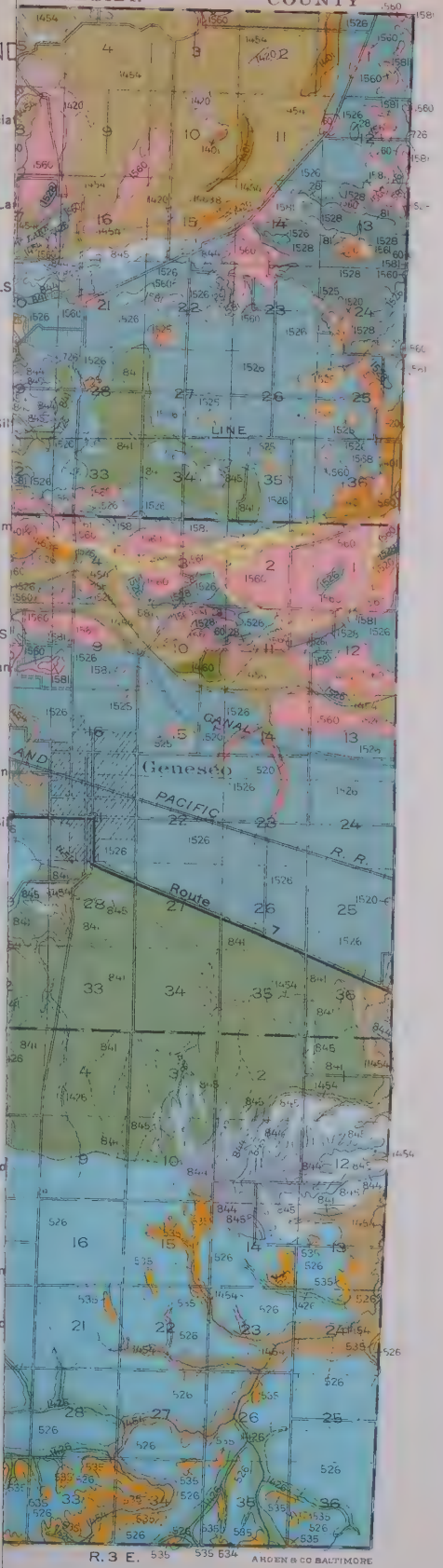
Animals and Animal Products	*Number*	*Value*
Horses	22,155	$2,193,837
Mules	867	112,503
Beef cattle	55,637	3,593,766
Dairy cattle	14,750	1,025,301
Sheep	13,215	167,622
Swine	140,286	3,310,466
Chickens and other poultry	352,134	368,371
Chickens and eggs sold	.....	550,815
Dairy products sold	.....	525,664

The total value of livestock and livestock products as shown by these figures, was nearly $12,000,000 in 1919.

Fruit growing is not important in Henry county and commercial vegetable growing is limited to certain areas of peat, particularly the one four miles north and a mile and a half east of Annawan, where a large acreage of onions is grown more or less regularly.

NORTHWEST SHEET

WHITESIDE COUNTY



LEGEND

200 Illinoisan Moraines

500 Upper Illinoisan Glacia

700 Iowan Glaciation

800 Deep Loess Areas

1400 Swamp and Bottom La

1500 Terrace

UPLAND PRAIRIE SOILS

226 526 728 — Brown Silt Loam

520 720 — Black Clay Loam

841 — Brown Fine Sandy Sil

560 760 — Brown Sandy Loam

528 728 — Brown-Gray Silt Loam

781 — Dune Sand

UPLAND TIMBER SOILS

234 534 734 — Yellow-Gray Silt Loan

235 535 735 — Yellow Silt Loam

844 — Yellow-Gray Fine San

845 — Yellow Fine Sandy Si

TERRACE SOILS

26 1526 — Brown Silt Loam

20 1520 — Black Clay Loam

17 1517 — Black Clay

25 1525 — Black Silt Loam

61 1561 — Black Sandy Loam

71 1571 — Brown Fine Sandy Lo

60 1560 — Brown Sandy Loam

28 1528 — Brown-Gray Silt Loan

68 1568 — Brown-Gray Sandy Lo

81 1581 — Dune Sand

INVOICE OF THE ELEMENTS OF PLANT FOOD IN HENRY COUNTY SOILS[1]

Three Depths Represented by Soil Samples

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.
2. A middle stratum extending from 6⅔ to 20 inches and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling we have represented separately three zones for plant feeding. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow, and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore it is the only stratum which can be greatly changed in composition as a result of adding fertilizers.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires to consider the information in that form. In comparing the composition of the different strata, it must be kept in mind that it is based on different quantities of soil, as indicated above. In order to show the comparative concentration of the various constituents in the different strata, the figures for the middle and lower strata must therefore be divided by two and three respectively.

Wide Range in Organic Matter and Nitrogen

It can readily be seen from Table 2 that there is a wide variation among the different soil types of Henry county with respect to their content of the different plant-food elements in the upper 6⅔ inches of soil. There appears to be but little relationship among these variations except with respect to organic carbon and nitrogen, the quantities of which run parallel from type to type tho the organic-carbon content is usually 10 to 12 times as great as the nitrogen. This relationship between organic carbon and nitrogen is explained by the well-established fact that all soil organic matter (of which organic carbon is the measure) contains nitrogen, and that most of the soil nitrogen—usually 98 per cent or more—is present in a state of organic combination, that is, as a part of the organic matter. This relationship is also maintained in the middle and lower sampling strata.

The range in soil content of organic matter and nitrogen is very wide. The upland prairie soils are for the most part relatively high in these constituents.

[1] In the chemical study of the Henry county soils, some samples representing the respective types were collected in bordering counties.

The upland timber soils are generally fairly low. The upland timber soils range from 13,650 pounds of organic carbon an acre in Yellow Fine Sandy Silt Loam up to 30,940 pounds in Yellow-Gray Silt Loam, with an average of 22,090 pounds. The upland prairie soils, exclusive of Dune Sand, range from 31,150 to 88,650 pounds, and average 55,380 pounds, or more than twice the amount found in the former group. Dune Sand is omitted from the average for upland prairie soils as given above. This, as is usually the case with very sandy soils, is very deficient in organic matter and nitrogen, the organic carbon amounting to only 12,420 pounds an acre in the surface stratum. The porous, open character of these soils permits the rapid oxidation of organic matter, so that it disappears from the soil much more rapidly than from the heavier types. Dune Sand is in fact but little more than the skeleton of a soil and cannot readily be brought up to, and maintained in, a state of productiveness without first incorporating active organic materials in it and continuing with frequent subsequent additions. The soil is usually acid and hence limestone and legume green manures constitute the first and most important steps in converting it into a productive soil.

The soils richest in organic matter and nitrogen are found in the terrace and bottom-land groups. Black Silt Loam contains the largest amount of organic carbon of any soil in the county except Deep Peat and Medium Peat, which are composed mainly of organic matter. The organic carbon of Black Silt Loam amounts to 188,480 pounds an acre, with a corresponding nitrogen content of 18,350 pounds. While such soils as this will withstand more abuse by the practice of continuous cropping than most soils, and are not so greatly in need of additions of organic carbon, yet the use of manure and the systematic growing of legumes for pasture and plowing down serve to renew the active organic material in the soil in a way which is reflected in increases of crop yields.

Phosphorus Content of Light-Colored Soils Relatively Low

With regard to total phosphorus, the upland timber soils on the whole are found to be the most deficient, while the bottom-land soils rank highest in this element. As is usually the case, Black Silt Loam and Black Clay Loam are outstanding types with respect to high phosphorus content. Black Silt Loam is high not only in phosphorus but in all other elements except potassium. This type, however, is not very extensive, occupying only 17.55 square miles or about 2 percent of the area of the county. As in the case of organic matter and nitrogen, Dune Sand resembles the upland timber soils in its low phosphorus content.

Phosphorus, in contrast with certain other elements, is not removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in these forms in plant residues at the expense of the underlying strata. Thus a portion of the soil phosphorus is also associated with soil organic matter. The second stratum (6⅔ to 20 inches) furnishes much of the phosphorus thus moved upward, altho obviously the lower stratum has also contributed. Consequently the surface soil generally contains a larger proportionate amount of phosphorus than the middle stratum and, in the majority of cases, more than the lower stratum.

200 Illinois
500 Upper
700 Iowan
800 Deep
1400 Swamp
1500 Terrac

UPLAND

226 526 726 Brow
520 720 Blacl
841 Brow
560 760 Brow
528 728 Brow
781 Dune

UPLAND

234 534 734 Yello
235 535 735 Yello
844 Yello
845 Yello

TERRACE

26 1526 Brow
20 1520 Blacl
17 1517 Blacl
25 1525 Blacl
61 1561 Blacl
71 1571 Brow
60 1560 Brow
28 1528 Brow
68 1568 Brow
81 1581 Dun

SWAMP AND BOTTOM-LAND SOILS

1426 Deep Brown Silt Loam
1420 Black Clay Loam
1454 Mixed Loam
1450 Black Mixed Loam
1463.8 Black Mixed Sandy Loam
1463.7 Brown Mixed Sandy Loam
1460 Brown Sandy Loam
1402 Medium Peat On Clay
1401 Deep Peat

CONVENTIONAL SIGNS

Swamps
Railroads
Public roads
Private roads
Interurbans
Canals
Morainal boundaries
Township lines
Paved roads

Scale

0 1/4 1/2 1 2 Miles

Sulphur Generally Well Supplied

While not so closely associated with each other as organic matter and nitrogen, there is some degree of correlation between sulfur, and organic carbon. This is because a considerable tho varying proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of the organic matter. Most of the Henry county soils are fairly well supplied with sulfur, the sandy types being the lowest. It ranges in the surface soil from a minimum of 260 pounds an acre in the upland Dune Sand to 2,800 pounds in Black Silt Loam, Terrace. These analyses show a sulfur content ranging for the most part from half to three-fourths as high as the phosphorus content, averaging approximately two-thirds as high. The peaty soils and the Black Silt Loam, all very high in organic matter, contain large quantities of sulfur, varying from 2,120 to 2,800 pounds an acre in the surface stratum, and in these the sulfur content is considerably greater than the phosphorus content.

The sulfur content decreases with increasing depth in nearly all cases, as may be seen from a comparison of the figures in Tables 2, 3, and 4. This is to be expected since, as stated above, a portion of the sulfur exists in combination with the organic matter of the soil, and not only is the organic matter more abundant in the upper stratum, but also the organic forms of sulfur are held more tenaciously against the leaching action of ground water than are the inorganic forms.

The sulfur available to crops, however, is affected not only by the soil supply, but also by that brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption the amount of sulfur thus added to the soil is relatively large. At Urbana during the eight-year period from 1917 to 1924 there has been added to the soil by the rainfall an average of 3.5 pounds of sulfur an acre a month. Similar observations have been made in other localities for shorter periods. The precipitation at the various points in the state in a single month has varied from a minimum of three-fourth of a pound to more than 10 pounds an acre.

These figures afford some idea of the amount of sulfur added by rain and also of the wide variations under different conditions. On the whole the facts would indicate that the sulfur added from the atmosphere supplements adequately that contained in the soil, so that apparently there is little need for sulfur fertilizers in Henry county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started on a number of the Illinois experiment fields.

Potassium Deficient in Peaty and Sandy Types

Potassium is deficient in Deep Peat and in Medium Peat, as is usually the case with these types, the total amounts in the upper 6⅔ inches of soil being 6,950 and 6,420 pounds an acre respectively. The sandy types of Henry county contain on the average only about two-thirds as much potassium as the mineral soils of finer texture. In addition to the handicap of smaller total quantities of

this element, sandy soils carry a considerable proportion of their potassium content in the coarse sand grains. The relatively smaller total surface exposed in the case of these coarser soil particles greatly reduces the rate at which potassium is dissolved, thus lowering its availability. This deficiency of available potassium in the sandy soils may be offset, at least in part, by the greater facility with which crop roots can penetrate soils of that character as compared with the heavier types.

The other soil types of Henry county are normal in their content of potassium. Potassium exhibits little difference in percentage in the three sampling layers.

Calcium and Magnesium Vary Widely Within the Type

The analyses show wide variations among the soil types in the amounts of calcium and magnesium present. Some are low in these elements, especially the sandy types. In very acid soils a sufficient amount of calcium is taken up with difficulty by growing crops from the comparatively insoluble forms in which it exists in such soils. The benefit realized from liming such soils may therefore be due, not wholly to the correction of acidity, but in part to the fact that the limestone supplies calcium as a plant-food element in a form which rapidly becomes available to crops.

Variations in the amounts of calcium and magnesium in the different depths furnish a clue as to the translocation of these elements during the long period in which the different types were developing. In the surface stratum calcium exceeds magnesium in most cases. This would indicate a larger percentage of calcium than of magnesium in the soil-forming materials. The idea is also in harmony with geological evidence. With increasing depth the concentration of calcium is usually about the same as in the surface, while in the case of magnesium the concentration increases progressively thru the middle and lower strata.

This situation may be explained by the fact that as these two elements are dissolved from the surface soil, they are carried downward in solution. In the downward movement magnesium is more readily reabsorbed by the soil mass than calcium, thus tending to force calcium into the solution to be carried farther down. Consequently, while magnesium tends to accumulate in the middle and lower strata, the liberated calcium may accumulate at still greater depths or may be washed away entirely. These movements of calcium and magnesium, as indicated by the analyses of the different strata, constitute one factor in estimating the relative maturity of the various soil types. The higher proportion of magnesium to calcium in the lower levels as compared to the surface soil tends, in general, to be accentuated with the more fully developed or mature soil profiles. Thus we see a correlation of this chemical characteristic of the soil with the processes of its development.

Some of the calcium values, as given in the tables, appear to be very erratic. The very large amounts of calcium in some of the types are an indication of the presence of finely divided native calcium carbonate (limestone). Sometimes calcium carbonate is present in the surface stratum, as in the case of Black Silt Loam with its high calcium figure of 55,570 pounds an acre. Again, being fairly soluble in the soil water calcium carbonate has leached away from the upper

TABLE 2.—HENRY COUNTY SOILS: PLANT-FOOD ELEMENTS IN UPPER SAMPLING STRATUM, ABOUT 0 TO 6⅔ INCHES[1]

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 500, 700, 800)							
226, 526, 726	Brown Silt Loam	72 030	5 030	1 190	820	32 680	8 790	12 160
520, 720	Black Clay Loam	88 650	7 290	1 740	1 350	30 690	12 710	22 010
841	Brown Fine Sandy Silt Loam	39 690	3 590	1 060	810	33 760	6 870	9 960
560, 760	Brown Sandy Loam	31 150	2 780	800	650	23 980	4 890	8 380
528, 728	Brown-Gray Silt Loam On Tight Clay	45 380	4 050	1 210	860	32 100	6 310	8 280
781	Dune Sand	12 420	1 020	480	260	17 280	3 720	5 480
	Upland Timber Soils (200, 500, 700, 800)							
234, 534, 734	Yellow-Gray Silt Loam	30 940	2 830	630	940	34 420	5 710	8 510
235, 535, 735	Yellow Silt Loam	25 600	2 270	820	390	34 100	6 980	7 530
844	Yellow-Gray Fine Sandy Silt Loam	18 160	1 820	840	480	34 820	3 920	9 940
845	Yellow Fine Sandy Silt Loam	13 650	1 470	880	440	35 490	5 920	8 960
	Terrace Soils (1500)							
1526	Brown Silt Loam	57 030	4 830	1 420	750	32 680	8 150	17 360
1520	Black Clay Loam	75 880	6 420	1 720	1 260	33 340	13 610	23 040
1517	Black Clay[2]	.....	.....	.....	.....	.....	.....	.....
1525	Black Silt Loam	188 480	18 350	2 310	2 800	24 890	13 660	55 570
1561	Black Sandy Loam	107 270	10 490	1 300	1 250	19 500	6 160	49 040
1571	Brown Fine Sandy Loam	62 360	5 020	1 680	1 000	27 840	3 760	9 840
1560	Brown Sandy Loam	34 510	2 920	1 020	620	24 580	4 830	8 620
1528	Brown-Gray Silt Loam On Tight Clay	51 740	4 510	1 420	870	31 590	5 410	8 850
1568	Brown-Gray Sandy Loam On Tight Clay	48 070	4 200	1 130	720	24 330	4 120	6 820
1581	Dune Sand	12 080	970	810	400	19 910	3 390	7 520
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	78 150	6 010	1 540	1 040	31 660	10 420	16 460
1420	Black Clay Loam	78 900	6 380	1 950	1 130	52 710	13 660	20 990
1454	Mixed Loam[3]	.....	.....	.....	.....	.....	.....	.....
1450	Black Mixed Loam[3]	.....	.....	.....	.....	.....	.....	.....
1463.8	Black Mixed Sandy Loam[3]	.....	.....	.....	.....	.....	.....	.....
1463.7	Brown Mixed Sandy Loam[3]	.....	.....	.....	.....	.....	.....	.....
1460	Brown Sandy Loam	60 960	5 110	1 540	890	25 380	6 340	15 640
1402	Medium Peat On Clay[4]	257 570	22 650	1 500	2 120	6 420	5 670	27 770
1401	Deep Peat[4]	283 110	26 020	1 550	2 760	6 950	5 410	21 620

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]In obtaining the average analyses as presented here samples of some of the types taken in adjacent counties are included. [2]No samples were obtained. [3]Analytical results are not included for the Mixed Loams because of the heterogeneity of these types. [4]Amounts reported are for 1 million pounds of Deep Peat and Medium Peat On Clay.

TABLE 3.—HENRY COUNTY SOILS: PLANT-FOOD ELEMENTS IN MIDDLE SAMPLING STRATUM, ABOUT 6⅔ TO 20 INCHES[1]

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 500, 700, 800)							
226, 526, 726	Brown Silt Loam	82 480	6 870	2 010	1 300	64 790	21 510	23 380
520, 720	Black Clay Loam	113 300	8 360	2 830	2 140	62 710	28 400	41 440
841	Brown Fine Sandy Silt Loam	50 940	4 790	1 910	1 290	69 960	15 250	19 630
560, 760	Brown Sandy Loam	35 540	3 320	1 320	910	52 780	11 470	14 820
528, 728	Brown-Gray Silt Loam On Tight Clay	41 630	4 130	1 760	1 160	67 680	16 180	16 550
781	Dune Sand	14 080	1 040	720	440	31 920	6 480	10 920
	Upland Timber Soils (200, 500, 700, 800)							
234, 534, 734	Yellow-Gray Silt Loam	25 540	2 520	1 540	590	69 120	17 290	15 660
235, 535, 735	Yellow Silt Loam	19 710	1 960	1 500	520	69 640	19 650	13 990
844	Yellow-Gray Fine Sandy Silt Loam	17 160	2 320	1 720	760	73 360	11 160	21 560
845	Yellow Fine Sandy Silt Loam	13 400	1 700	2 320	840	68 820	14 120	21 220
	Terrace Soils (1500)							
1526	Brown Silt Loam	62 880	5 380	1 900	1 280	73 240	15 860	21 880
1520	Black Clay Loam	93 060	7 900	3 600	1 760	67 480	23 640	40 940
1517	Black Clay[2]							
1525	Black Silt Loam	252 520	20 440	3 840	4 480	49 200	26 730	102 740
1561	Black Sandy Loam	69 570	5 570	1 680	1 130	41 050	11 440	48 090
1571	Brown Fine Sandy Loam	40 880	3 520	1 760	1 200	73 040	9 400	20 120
1560	Brown Sandy Loam	39 770	3 430	1 710	940	50 790	10 000	15 010
1528	Brown-Gray Silt Loam On Tight Clay	48 410	4 270	2 340	1 040	66 500	13 400	13 440
1568	Brown-Gray Sandy Loam On Tight Clay	28 250	2 650	1 870	860	54 920	10 000	12 620
1581	Dune Sand	11 950	1 050	1 350	760	39 790	6 970	15 360
	Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	90 700	6 040	1 960	1 040	63 180	22 960	29 900
1420	Black Clay Loam	95 410	8 050	3 150	1 540	66 420	28 730	40 760
1454	Mixed Loam[3]							
1450	Black Mixed Loam[3]							
1463.8	Black Mixed Sandy Loam[3]							
1463.7	Brown Mixed Sandy Loam[3]							
1460	Brown Sandy Loam	67 690	5 950	2 570	1 120	52 640	16 440	39 400
1402	Medium Peat on Clay[4]	226 300	20 480	1 860	3 910	20 800	11 980	47 520
1401	Deep Peat[4]	521 320	44 010	2 610	5 690	12 870	9 660	44 830

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]In obtaining the average analyses as presented here samples of some of the types taken in adjacent counties are included. [2]No samples were obtained. [3]Analytical results are not included for the Mixed Loams because of the heterogeneity of these types. [4]Amounts reported are for 2 million pounds of Deep Peat and Medium Peat On Clay.

TABLE 4.—HENRY COUNTY SOILS: PLANT-FOOD ELEMENTS IN LOWER SAMPLING STRATUM, ABOUT 20 TO 40 INCHES[1]

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
Upland Prairie Soils (200, 500, 700, 800)								
226, 526, 726	Brown Silt Loam	40 560	4 100	2 580	1 470	100 660	43 710	39 940
520, 720	Black Clay Loam	46 560	3 510	3 710	1 540	97 370	48 540	55 130
841	Brown Fine Sandy Silt Loam	30 910	3 440	2 870	1 460	102 560	29 870	33 110
560, 760	Brown Sandy Loam	22 730	1 970	1 710	1 010	75 360	19 140	27 360
528, 728	Brown-Gray Silt Loam On Tight Clay	29 220	3 240	2 990	740	99 990	41 570	32 900
781	Dune Sand	9 900	540	1 020	900	50 100	12 480	17 940
Upland Timber Soils (200, 500, 700, 800)								
234, 534, 734	Yellow-Gray Silt Loam	18 120	2 490	3 140	970	100 790	40 740	30 160
235, 535, 735	Yellow Silt Loam	18 730	2 110	2 730	610	105 220	39 140	41 020
844	Yellow-Gray Fine Sandy Silt Loam	15 360	2 220	3 600	1 320	106 740	24 000	37 200
845	Yellow Fine Sandy Silt Loam	15 000	1 740	3 840	930	103 650	24 960	38 460
Terrace Soils (1500)								
1526	Brown Silt Loam	36 450	3 130	2 910	1 020	106 740	34 680	32 580
1520	Black Clay Loam	47 130	4 590	4 230	1 770	103 410	35 910	51 990
1517	Black Clay[2]	.....	.....	.....	.....	.....	.....	.....
1525	Black Silt Loam	75 090	8 370	4 810	1 460	84 630	48 100	225 450
1561	Black Sandy Loam	32 360	2 140	1 960	1 060	66 780	21 280	40 400
1571	Brown Fine Sandy Loam	22 320	2 280	2 580	1 020	95 400	16 380	31 020
1560	Brown Sandy Loam	22 820	2 170	2 000	760	75 210	16 350	22 050
1528	Brown-Gray Silt Loam On Tight Clay	29 610	3 180	3 000	930	90 170	31 280	26 930
1568	Brown-Gray Sandy Loam On Tight Clay	21 060	2 080	2 720	940	73 660	19 640	19 450
1581	Dune Sand	11 690	810	1 760	710	59 990	18 330	36 490
Swamp and Bottom-Land Soils (1400)								
1426	Deep Brown Silt Loam	49 290	3 390	2 730	540	102 210	36 030	42 210
1420	Black Clay Loam	67 700	5 290	4 850	1 940	95 570	45 820	67 400
1454	Mixed Loam[3]	.....	.....	.....	.....	.....	.....	.....
1450	Black Mixed Loam[3]	.....	.....	.....	.....	.....	.....	.....
1463.8	Black Mixed Sandy Loam[3]	.....	.....	.....	.....	.....	.....	.....
1463.7	Brown Mixed Sandy Loam[3]	.....	.....	.....	.....	.....	.....	.....
1460	Brown Sandy Loam	57 260	3 860	3 500	1 280	72 320	43 900	162 540
1402	Medium Peat On Clay	76 440	5 820	3 240	1 800	60 540	66 720	625 860
1401	Deep Peat[4]	531 750	40 380	2 860	8 120	25 510	17 580	163 660

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]In obtaining the average analyses as presented here samples of some of the types taken in adjacent counties are included. [2]No samples were obtained. [3]Analytical results are not included for the Mixed Loams because of the heterogeneity of these types. [4]Amounts reported are for 3 million pounds of Deep Peat.

stratum of some soils but is still present in abundance in the middle or in the lower stratum. Brown Sandy Loam, Bottom, illustrates such a condition. Here the lower stratum has 162,540 pounds of calcium in 6 million pounds of soil, which after being converted to the 2-million pound basis for comparison with the surface stratum is found to be more than three times as concentrated. The lower stratum in this case contains a large amount of calcium carbonate which has not yet been leached away, and this is responsible for the high value for total calcium.

Some increase in total magnesium will be observed accompanying the high calcium of the carbonate-containing soils. These are not great, however, because of the inability of magnesium to exist long in the soil as carbonate. The carbonate of carbonate-containing soils is chiefly calcium carbonate.

Local Tests for Soil Acidity Often Required

It is impracticable to attempt to obtain an average quantitative measure of the calcium carbonate present or of the lime requirement in many soil types because while some samples may contain large amounts of carbonate others may contain none and, on the other hand, may actually have a lime requirement owing to the soil acidity. We thus have what may be considered positive and negative values ranging, perhaps widely, on the opposite sides of the zero or neutral point, the numerical average of which could have no significance whatever since it would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types.

The qualitative tests made in the field in the process of the soil survey are much more numerous than the chemical analyses made in the laboratory and do give a general idea of the predominating condition in the various types as to acidity or alkalinity. These tests, therefore, furnish the basis for some general recommendations, which are given in the descriptions of individual types on pages 16 to 26. To have a sound basis for the application of limestone, the owner or operator of a farm must frequently determine individually the lime requirements of his different fields. The section in the Appendix dealing with the application of limestone (page 35) is pertinent and should be read in this connection.

Supplies of Different Elements Not Proportional to Crop Removal

In the foregoing discussion consideration has been given mainly to the amounts of the plant-food elements in the surface 6⅔ inches of soil, and rather briefly the relative amounts in the two lower strata have been discussed. It has been noted that some of the elements of plant food exhibit no consistent change in amount with increasing depth. Other elements show more or less marked variation at the different levels, the trend of these variations serving in some cases as clues to the relative maturity of different soil types and the processes involved in their development.

By adding together the figures for all three strata, we have an approximate invoice of the total plant-food elements within the reach of most of our common

field crops since their feeding range is included mainly in the upper 40 inches of soil. One of the most striking facts brought out of this consideration of the data is the great variation within a given soil type in the relative abundance of the various elements present as compared to the amounts removed by crops. For example, in the most extensive type in the county, Brown Silt Loam, Upland, we find that the total quantity of nitrogen in all three strata is 16,000 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus is only about a third as much, or 5,780 pounds, but this amount is equivalent to the phosphorus in more than twice as much corn, namely, 34,000 bushels. The total stock of potassium, amounting in this type to 198,130 pounds an acre, would furnish this element for more than a million bushels of corn.

Service of Chemical Analysis in Soil Improvement

The foregoing discussion should not be taken to mean that it is possible to predict how long any certain soil could be cropped under a given system before it would become exhausted. Nor do the figures alone necessarily indicate the immediate procedure to be followed in the improvement of a soil. It must be kept in mind that the amount of plant-food substances shown to be present is not the sole measure of the ability of a soil to produce crops. The *rate* at which some of these elements are liberated from insoluble forms and converted to forms that can be used by growing plants is a matter of at least equal importance, as explained on page 33, and is not necessarily proportional to the total stocks present. One must know, therefore, how to cope with the peculiarities of a given soil type if he is to secure the full benefit from its stores of plant-food elements. In addition there are always economic factors that must be taken into consideration, since it is necessary for one to decide at how high a level of productive capacity he can best afford to maintain his soil.

The chemical soil analysis made in connection with the soil survey is seen to be of value chiefly in two ways. In the first place it reveals at once outstanding deficiencies or other chemical characteristics which alone would affect its productivity to a marked extent or point the way to corrective measures. It should be borne in mind, however, that fairly wide departures from the usual are necessary before the chemical analysis alone can be followed as a guide in practice without supplementary information from other sources. It is quite probable that the results of the soil analysis are frequently misused by attempting to interpret small differences in the amount of a certain plant-food element as indicative of similar differences in the fertilizer need.

The second function of soil analysis is as an aid in the scientific study of soils from many angles, the ultimate aim of which is, of course, the more economical utilization of the soil for efficient crop production. Not only do chemical studies aid in determining the processes involved in soil development under natural conditions, but also in determining the effects of different soil management and fertilizing practices upon the soil itself and in furthering our knowledge of the interrelations between the soil and growing crops, a knowledge which is fundamental to improvement in the efficiency of crop production.

DESCRIPTION OF SOIL TYPES

UPLAND PRAIRIE SOILS

The upland prairie soils of Henry county occupy 407.58 square miles, or almost exactly 50 percent of the area of the county. These soils were originally well supplied with organic matter derived very largely from the fibrous roots of the prairie grasses that grew on this land for centuries. A covering of fine soil and a mat of vegetative material, by partially excluding the oxygen, protected these roots from rapid and complete decay. From time to time the mat of old grass stems and leaves was partially destroyed by prairie fires and decay, but it was constantly being renewed, and while it added but little organic matter to the soil directly, it served to retard the decay of the roots of the grasses.

Brown Silt Loam (226, 526, 726)

Brown Silt Loam, Upland, as mapped in Henry county, covers an area of 373.6 square miles, or nearly 46 percent of the county. The type as originally mapped is now recognized to consist of three types each having a characteristic topography. These three types which, taken together, constitute Brown Silt Loam as shown on the soil map, may be described as follows:

Light Brown Silt Loam. This type occupies the tops of low hills and ridges and the more pronounced slopes. Its development has been associated with the relatively rapid removal of the surface soil by erosion and with good surface drainage and underdrainage. These conditions have resulted, in this region, in the formation of a soil which is very friable thruout its entire profile. The A_1 horizon, or surface soil, is about 8 inches in thickness and is a light brown silt loam. The A_2 horizon, or subsurface, extends to 15 or 20 inches in depth and has a yellowish brown color which gradually changes to a reddish brown in the B horizon, or upper subsoil. Slight gray mottling appears at a depth of 30 to 35 inches where the less-weathered parent material is found. Effervescence with acid probably never occurs in the 40-inch section of this soil and is not usually found within 60 inches of the surface.

Management.—Light Brown Silt Loam is not strongly acid but requires an application of limestone to grow red clover satisfactorily, and it will not grow alfalfa or sweet clover without the addition of limestone. The conditions of its formation have not been favorable for the accumulation of organic matter and it is lower in this essential soil constituent than is usual for the prairie soils in this region. The best information available on the treatment of this type comes from the Mt. Morris experiment field, which is located in part on Light Brown Silt Loam. The results from this field show a very marked response to manure. Where limestone was applied in addition to manure, a further increase was secured which was sufficiently large to pay a good profit on the cost of the limestone. Another treatment which gave very good increases on this field was residues and limestone used in combination. Potash has not increased the yields. Rock phosphate when used in addition to manure and limestone has not increased yields, and when used in addition to residues and limestone the yields have been increased just about enough to pay for applying half a ton of the rock per acre once in the rotation. For further account of these experiments see page 46.

Brown Silt Loam. This type occupies intermediate topographic positions. It differs from the preceding type, Light Brown Silt Loam, in having a darker and usually thicker A_1 horizon or surface, and a heavier, less friable, and somewhat mottled B horizon or upper subsoil.

Management.—Brown Silt Loam is somewhat less acid than Light Brown Silt Loam but requires limestone to grow alfalfa or sweet clover. It was originally well supplied with organic matter and has been subject to but little loss of soil material thru erosion. The Kewanee experiment field is located, for the most part, on this soil type. Unfortunately this field has several draws crossing the plots which are a much heavier soil, so that the results from the field cannot be applied to Brown Silt Loam with as much confidence as would otherwise be the case. It is almost certainly true, however, that the presence of the heavier type on the Kewanee field has the effect of diminishing the increases due to treatment. The records from this field show good results for manure with corn and oats and fair results with wheat. Limestone has given moderate increases both in the manure and in the residues system. Rock phosphate has increased the yield of wheat on the manure plots by 4.9 bushels but has had little or no effect on the other crops in the rotation. On the residues plots rock phosphate has caused very satisfactory increases in the yields of corn, oats, and wheat, and has increased the yield of clover hay by a fifth of a ton. The comparison of rock and acid phosphate on the Kewanee field has been in progress too short a time to allow final conclusions. A detailed description and history of the Kewanee experiments will be found beginning on page 48. The only concrete suggestion for the phosphate fertilization of this soil type which can be made at the present time is to make a trial of one of the phosphates, applying it for the wheat crop.

Brown Silt Loam on Clay. This type occupies the nearly level or only gently sloping areas in the upland prairie region. It is characterized by a dark brown A_1 horizon, or surface, about 10 inches thick; a brown A_2 horizon, or subsurface, containing pale yellow spots; and a B horizon, or upper subsoil, which is usually a strongly mottled, brownish yellow, somewhat compact and plastic clay loam. At a depth of 32 to 40 inches the more friable C horizon, or lower subsoil, is found.

Management.—This type is either not acid or only slightly so. The subsoil, while more compact and plastic than that of either of the preceding types discussed, drains well with tile. The Aledo experiment field is located on Brown Silt Loam On Clay, and the results from this field may be used as a guide in the treatment of this soil type in Henry county. Manure has given very good returns. Limestone has failed to give very convincing increases and its indiscriminate use could hardly be advised unless alfalfa or sweet clover is to be grown. Rock phosphate has not caused increases in yield on the manure plots but its use on the residues plots has resulted in sufficiently large increases to justify advising its application when manure is not available. Phosphate comparisons have been in progress on the Aledo field since 1916, and the reader is asked to turn to page 55 of this Report and make a study of the results as an aid in solving his phosphate problem on Brown Silt Loam On Clay.

Black Clay Loam (520, 720)

This upland phase of Black Clay Loam is a minor type in Henry county, occupying a total area of less than a square mile. It occurs as small, low-lying areas in the dark-colored upland portion of the county. It has a deep A_1 horizon, or surface soil, consisting of black clay loam or silty clay loam. The A_2 horizon, or subsurface, is a drabbish black clay loam and occurs at a depth of 12 to 18 inches. The *B* horizon, or upper subsoil, is found at a depth of about 24 inches and consists of a gray clay loam heavily colored with reddish brown spots and concretions. The more friable *C* horizon, or lower subsoil, occurs at a depth of about 36 inches. It is a strongly mottled, reddish brown, silty clay loam. The color of this horizon changes to gray at a depth of 38 or 40 inches.

Management.—Black Clay Loam, Upland, as it occurs in Henry county is likely to be alkaline tho not all of the areas have this characteristic. None of the areas, so far as is known, need limestone. The only treatment advised is the use of potash where alkali is present in harmful amounts and the plowing down of fresh organic matter as an aid in keeping the soil in good physical condition.

Brown Fine Sandy Silt Loam (841)

Brown Fine Sandy Silt Loam occupies a total area in this county of about 30 square miles. The character of this type varies somewhat depending on topography. In the hilly portion of the type the surface is a very light brown fine sandy loam underlain by yellow fine sandy loam with no visibly distinguishable subsurface or subsoil development. Carbonates occur at a depth of 20 to 30 inches on many of the hills. On the low divides and low hills the soil is different in that the surface is darker and the subsurface and subsoil are sufficiently well formed to be distinguishable, tho there is no compactness in the subsoil and mottling is absent. Carbonates are rarely found in the 40-inch section in this phase of the type. A third phase of the type occurs on the gentle slopes, the soil differing here from that on the low hills and low divides chiefly in having a lightly mottled and slightly compact subsoil. Still another phase of this same type occurs in the low level areas; it is characterized by a darker surface and a well-mottled and fairly compact medium-plastic subsoil.

Management.—Brown Fine Sandy Silt Loam is a productive soil, very easy to work. Particular attention should be given to maintaining a supply of fresh organic matter. A light application of limestone is needed for alfalfa or sweet clover. There are no experiment field data upon which to draw for definite statements regarding its fertilization. The use of manure will prove profitable and the trial of the various phosphates is suggested.

Brown Sandy Loam (560, 760)

Brown Sandy Loam, Upland, is a minor type in Henry county, its total area being only about 1¼ square miles. It is found in association with Dune Sand and occurs in depressions or low-lying areas between ridges or low hills formed by the drifting of the sand. This type varies in character, in some places having such a coarse subsoil as to be drouthy and of little value. In general the

A_1 horizon, or surface, is a brown sandy loam; the A_2 horizon, or subsurface, a yellowish brown sandy loam; and the B horizon, or upper subsoil, a slightly clayey sandy loam.

Management.—Brown Sandy Loam, Upland, should be cropped and managed in such a way as to provide for regular and frequent additions of either leguminous organic matter or manure. The type is not strongly acid but most of it requires some limestone to grow good sweet clover.

Brown-Gray Silt Loam On Tight Clay (528, 728)

The upland phase of Brown-Gray Silt Loam On Tight Clay is another one of the minor types in Henry county, aggregating a total of only one square mile. It occurs chiefly between Cambridge and Bishop Hill. The A_1 horizon, or surface soil, is about 8 inches thick and is a grayish brown silt loam. The A_2 horizon, or subsurface, is a gray or brownish gray silt loam, about 10 inches in thickness. The B horizon, or upper subsoil, is heavy and plastic and is not readily permeable to air, water, or plant roots.

Management.—The chief problem in the management of this type is to secure drainage. Underdrainage is not successful and furrows and open ditches must therefore be depended on for the removal of excess water.

Dune Sand (781)

Dune Sand, Upland, occupies all told only about a square mile. It differs in no essential, other than that of position, from Dune Sand, Terrace, and the reader is therefore referred to the discussion of the latter type (page 24).

UPLAND TIMBER SOILS

The upland timber soils are found fairly well distributed thruout the county, adjacent to the streams. Usually they are characterized by a yellow or yellowish gray color, owing to their low organic-matter content. This lack of organic matter has been caused by the long-continued growth of forest trees. As the forests invaded the prairies, the following effects were produced: the shading of the trees prevented the growth of grasses, the roots of which are mainly responsible for the large amount of organic matter in the prairie soils; and the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed or were destroyed by forest fires. The timber soils cover about 104 square miles, or about 13 percent of the area of the county.

Yellow-Gray Silt Loam (234, 534, 734)

Yellow-Gray Silt Loam occupies a total area of 22 square miles in Henry county. The topography of the type varies from flat to rolling, and associated with this variation is also a variation in the character of the soil. The rolling, well-drained areas have a brownish gray A_1 horizon, or surface, a yellowish brown A_2 horizon, or subsurface, and a friable, slightly compact, reddish yellow B horizon, or upper subsoil. The C horizon, or lower subsoil, is a mottled, pale yellow, friable, fine sandy loam. The soil on the intermediate slopes differs from the above in having a distinctly gray subsurface, a mottled, medium-compact

upper subsoil, and brownish-red iron stains and concretions thruout the upper and lower subsoil.

The flat areas have a gray silt loam A_1 horizon, or surface, a light gray A_2 horizon, or subsurface, and a very compact, strongly mottled, plastic, pale yellow clay loam *B* horizon, or upper subsoil.

Management.—The differences within this type, as noted above, should be taken into account in planning a management program. The rolling land is subject to harmful erosion, while the intermediate slopes and flat areas do not wash. The friable subsoil found in the rolling land favors good underdrainage, while the underdrainage of the flat areas is poor. As a rule the rolling land is less acid than the flat land. The entire type is low in organic matter and nitrogen. These deficiencies should be corrected by growing clover, preferably sweet clover, following the application of limestone. No experiment field data is available for this soil type as it occurs in Henry county; consequently no definite recommendations can be made for its fertilization. It is suggested, however, that the reader turn to the discussion of "Principles of Soil Fertility," page 30, and make use of the information found in that discussion in forming his plans for fertilizer treatment.

Yellow Silt Loam (235, 535, 735)

Yellow Silt Loam covers a total of nearly 60 square miles in Henry county. It occurs for the most part as the inner timber soil belt adjacent to the bottom land along streams. Much of this type as it occurs in Henry county is too steep for cultivation and is used for pasture and timber. It is not uncommon, however, to see slopes under cultivation which are so steep as to be subject to serious erosion. No attempt is made to describe the soil itself because it varies so greatly. The separation of Yellow Silt Loam as a type is really based upon topographic rather than upon soil characteristics.

Some suggestions regarding the possibility of controlling erosion on this kind of land are given in an account of the Vienna experiment field, page 60.

Yellow-Gray Fine Sandy Silt Loam (844)

A total of nearly 11 square miles of Yellow-Gray Fine Sandy Silt Loam occurs in Henry county. The character of its profile bears the same relation to topography as was described for Yellow-Gray Silt Loam, page 19. The A_1 horizon, or surface, is a grayish yellow fine sandy loam. The A_2 horizon, or subsurface, is a reddish yellow or grayish yellow fine sandy loam depending on topography. The *B* horizon, or upper subsoil, is usually a reddish brown, medium-compact, non-plastic, fine sandy silt loam. This soil has been formed under timber vegetation from the wind-blown material which was blown upon the upland from the terrace.

Management.—For suggestions regarding the management of this type the reader is referred to the management paragraph for Yellow-Gray Silt Loam.

Yellow Fine Sandy Silt Loam (845)

There is an aggregate of nearly 12 square miles of Yellow Fine Sandy Silt Loam in Henry county. This type has no uniformly developed profile, its

topography being such that erosion is more or less active, depending largely on its vegetative cover. Most of the type should be used for pasture or timber. Many of the slopes are well adapted to growing alfalfa and frequently no lime is needed for alfalfa because erosion has exposed the underlying calcareous material. The possibility of orcharding might well be considered by owners of this land.

TERRACE SOILS

Large areas of terrace soils occur in Henry county as a result of the changes which have occurred in the river systems. The terraces were formed by overloaded and flooded streams which deposited an immense amount of material in the old channels. Later as the streams diminished in size or cut their channels deeper, new bottoms were developed, leaving the old flood plains above the overflow and thus forming terraces. These terrace formations which were built up, for the most part, during and immediately following the Glacial period, were later covered to varying depths with wind-blown material from which the present soils were formed.

Brown Silt Loam (1526)

Nearly 83 square miles of Brown Silt Loam, Terrace, is shown on the soil map of Henry county. The areas of this type which occupy the higher portions in the undulating terrace plain are similar to Brown Silt Loam, which occupies the intermediate topographic positions on the upland (see page 17). The areas occupying the lower-lying positions differ from the higher areas in that they have a slightly grayer A_2 horizon, or subsurface, and a very gray B horizon, or subsoil. These lower-lying areas are sometimes alkaline.

Management.—Brown Silt Loam, Terrace, is a productive soil with the exception of small areas which are so situated as to be alkaline or to have an unfavorable subsoil. Limestone is needed, except on the low areas, for alfalfa and sweet clover and for the best growth of red clover. Potash can be successfully used to correct the harmful effects of alkali, and the underdrainage of these low spots should be improved. This type was originally well supplied with organic matter but much of it is now beginning to show a deficiency in this important soil constituent. If any of the phosphates are used they should be applied at first in an experimental way, as the information available is not sufficient to warrant recommending their use on a large scale.

Black Clay Loam (1520)

Black Clay Loam, Terrace, is a rich, highly productive soil. Portions of the type need better drainage and alkali is present in places. There is a total of over 15 square miles of the type in the county.

The A_1 horizon, or surface, is a black clay loam or silty clay loam which varies from 9 to 12 inches in thickness. The A_2 horizon, or subsurface, extends to a depth of 19 to 22 inches, is a drab clay loam, and in places contains reddish brown iron spots. The B horizon, or upper portion of the subsoil, is medium-plastic drab clay or clay loam, sometimes containing reddish brown spots and concretions, while the lower portion, usually beginning at a depth of about 36 inches, is gray heavily colored with reddish brown.

Management.—Black Clay Loam, Terrace, rarely needs lime, and for the ordinary field crops it is questionable whether it will respond profitably to fertilization. Particular care should be used to provide for plowing down fresh organic matter at frequent intervals; otherwise this soil will rapidly become difficult to work. The work on the Hartsburg experiment field located on Black Clay Loam on Drab Clay is of interest in this connection. An account of the results on that field will be found on page 59.

Black Clay (1517)

Black Clay occurs in one large area of 12.78 square miles north of Atkinson. Portions of this area are better described as clay loam rather than clay. The water table is high and there is considerable alkali present. During seasons of high rainfall the crops suffer from excess water. The A_1, or surface, horizon is principally black clay, passing into the drabbish black clay A_2, or subsurface, horizon at a depth of about 8 inches. At a depth of about 15 inches the color becomes drab, and at about 20 inches a marly gray clay is frequently encountered.

Management.—Black Clay is a rich soil but must be worked with care because of its heavy nature. Organic materials should be plowed down to help keep it in good physical condition. No fertilizer treatment is advised other than the application of potash where necessary to counteract the alkali.

Black Silt Loam (1525)

Black Silt Loam is a soil formed under swampy conditions. Frequently it is strongly alkaline and the subsoil in many places is marly. It occupies a total of about 17.5 square miles in Henry county.

The surface soil varies from a black silt loam to a black silty clay loam. It frequently contains sufficient carbonates to effervesce strongly with acid. The subsurface is a drabbish-black clay loam or silty clay loam, and the subsoil is usually either a strongly mottled, rusty yellow, sandy clay loam or a more or less pure marl.

Management.—Improved drainage is the chief requirement of this type. Limestone should not be added, as carbonates are already present in excess. The bad effects of the alkali may be counteracted by the use of potash for corn. The application of coarse manure is also advised as an additional means of counteracting the effects of the alkali.

Black Sandy Loam (1561)

Black Sandy Loam is similar in formation to the preceding type, Black Silt Loam. It is much less extensive, occupying a total of about 6 square miles. It is sometimes alkaline. The surface, or A_1 horizon, varies from a brown to black sandy loam. The subsurface, or A_2 horizon, usually extending to a depth of about 21 inches, is a drabbish brown sandy silt loam. The subsoil, or B horizon, is a drab sandy clay loam, usually resting on gray sand at a depth of about 36 inches.

Management.—Fresh organic matter should be regularly plowed down in this soil. In places the underlying sand stratum is near enough to the surface

to make the soil drouthy. Limestone is ordinarily not needed on this type, tho it is much more likely to be needed than on Black Silt Loam because of the leachy subsoil.

Brown Fine Sandy Loam (1571)

Brown Fine Sandy Loam, Terrace, is a minor type in Henry county, aggregating little more than one square mile. It occurs in the northeast corner of the county. The surface, or A_1 horizon, is a light brown fine sandy loam resting at a depth of 7 or 8 inches on the subsurface, or A_2 horizon, which is a slightly reddish brown fine sandy loam. The subsoil, or B horizon, which is found at a depth of about 18 inches, is a reddish yellow, friable, fine sandy silt loam. Usually a reddish yellow sand occurs at a depth of about 36 inches.

Management.—This type is low in organic matter and nitrogen and is medium acid. Following the application of 2 to 3 tons of limestone an acre, it will grow good alfalfa or sweet clover. Corn or the small grains will do well following the turning down of clover.

Brown Sandy Loam (1560)

Brown Sandy Loam, Terrace, is pretty well distributed thruout the northern part of Henry county and covers a total area of nearly 30 square miles. This type has been subject to more or less movement by wind action and consequently much of it has not developed very definite subsurface and subsoil strata. The surface, or A_1 horizon, to a depth of 8 or 10 inches is usually a light brown sandy loam. It usually rests on a yellowish brown sandy loam which becomes more yellow and more sandy with depth. In some places there is enough accumulation of fine particles in the subsoil, or B horizon, to give it some cohesion.

Management.—Brown Sandy Loam, Terrace, is medium acid, low in organic matter and nitrogen, and where there is no accumulation of fine particles in the subsoil, it is likely to be drouthy. This soil grows good sweet clover following the application of limestone. If the sweet clover is plowed down, good corn or small grain can be grown. A clover crop should be grown every third or fourth year and utilized, at least in part, for soil improvement.

Brown-Gray Silt Loam On Tight Clay (1528)

Brown-Gray Silt Loam On Tight Clay, Terrace, occupies about 7 square miles in Henry county. The surface, or A_1 horizon, is a grayish brown silt loam, in places containing so much sand as to be sandy loam. The subsurface, or A_2 horizon, usually extending to a depth of about 17 inches, is a gray or grayish drab silt loam to sandy loam. The subsoil, or B horizon, varies considerably in color and in sand content but is impervious and plastic. In some places this impervious layer or horizon extends to over 40 inches in depth, and in other places it rests on gray sand at a depth of about 36 inches.

Management.—Both the surface drainage and the underdrainage of this type are poor. The soil is medium to strongly acid. Much of the land is used for pasture. Its value as pasture can be greatly increased by applications of limestone and the seeding of sweet clover, and probably pasture is the best use to which it can be put.

Brown-Gray Sandy Loam On Tight Clay (1568)

Less than one square mile of Brown-Gray Sandy Loam On Tight Clay, Terrace, as mapped, occurs in Henry county. The reader is referred to the discussion of the preceding type, 1528, as that discussion applies to this type also. The sandy loam, however, is a poorer soil than the silt loam.

Dune Sand (1581)

Dune Sand, Terrace, occupies nearly 18.5 square miles in Henry county. It has been subject to much movement by the wind and has developed few of the characteristics of a true soil. The surface is a light brown sand and rests at a depth of 6 or 7 inches on yellow sand. No further signs of the usual characteristic subsurface or subsoil development appear.

Management.—Dune Sand is somewhat acid and the correction of this condition by the use of limestone is the first step towards the profitable utilization of this type. The Oquawka experiment field is located on Dune Sand and very striking results have been secured there with limestone and manure, and limestone and sweet clover. The reader is referred to page 63, where the crop yields on this field are given. The information given by these figures is the best available for Dune Sand, either Terrace or Upland, as it occurs in Henry county.

SWAMP AND BOTTOM-LAND SOILS

The following group of soil types includes the bottom lands along the streams and certain poorly drained lowlands. The total area of this group, consisting of nine soil types, is a little over 110 square miles.

Deep Brown Silt Loam (1426)

Deep Brown Silt Loam occurs in the bottom lands in the southern half of the county. It is most extensively developed along Edwards river. The soil is a deep, rich silt loam. It has no distinct subsoil development, because of its youth.

Management.—Much of this land is subject to overflow and is farmed in such a way as to avoid many of the harmful effects of flood water. No fertilizer treatment is advised on any of this type which is subject to overflow. The areas not subject to overflow should be treated in the same way as Brown Silt Loam, Upland, which it resembles (see page 17).

Black Clay Loam (1420)

Black Clay Loam, Bottom, is a minor type in Henry county occupying a total area of about 1¼ square miles. This type is very similar to Black Clay Loam, Upland, and for a description of it and for suggestions regarding its management the reader is referred to the discussion of that type, page 18.

Mixed Loam (1454)

Mixed Loam occurs along the streams where conditions are such that different kinds of soil material have been washed in and deposited, resulting in what is called Mixed Loam. The soil is young and no distinct horizons have yet

been formed. Most of this type is farmed and it produces good crops, tho the farming plan has to take into account the overflow to which this land is subject. The large area of this type in the northwest corner of the county has some alkali spots, the effects of which can be overcome with potash. The areas which are not subject to overflow show slight to medium acidity, indicating the need of a moderate application of lime in a well-planned program of soil improvement, (see Brown Silt Loam, page 17).

Black Mixed Loam (1450)

Black Mixed Loam differs from Mixed Loam, 1454, in that it contains much more organic matter, has more heavy spots scattered thru it, is usually more poorly drained, and has more alkali spots. It is a productive soil and needs no treatment other than the use of potash where alkali is present, the improvement of the drainage where possible, and the provision for the addition of fresh organic matter at intervals of four or five years.

Black Mixed Sandy Loam (1463.8)

Black Mixed Sandy Loam is not essentially different from the preceding type, Black Mixed Loam (1450), except that, aside from the generally higher percentage of sand in the soil, many sandy spots are present, too small to be shown on the map. This type should be handled in the same general way as Black Mixed Loam but with more attention to the addition of organic matter.

Brown Mixed Sandy Loam (1463.7)

Brown Mixed Sandy Loam is a minor type in Henry county, aggregating only about 1⅓ square miles. It is low in organic matter and is medium acid. It is frequently underlain by nearly pure sand at a depth of about 36 inches. Because of its drouthy nature this land if farmed should be cropped to wheat, barley, or rye rather than to corn. Limestone should be used and legumes grown to furnish organic matter and nitrogen.

Brown Sandy Loam (1460)

Brown Sandy Loam, Bottom, is very similar to Brown Mixed Sandy Loam described above. It differs from it in being uniformly a sandy loam. The two types should be handled in the same way.

Medium Peat On Clay (1402)

Three small areas of Medium Peat On Clay, aggregating 122 acres, were identified at the time the soil map was made. They were located about three miles northeast of Annawan. The peat, which was less than 30 inches in thickness at that time, disappeared rapidly under cultivation, and it no longer exists as Medium Peat On Clay. These areas are now similar to the surrounding type, Black Silt Loam, and should be handled in the same way as that type.

Deep Peat (1401)

A considerable acreage of Deep Peat, aggregating 7.47 square miles, occurs in Henry county. It consists of a deposit of black, well-decomposed organic matter, frequently 5 or 6 feet in thickness. Its location near sandy areas has resulted in the drifting of sand to the Peat, frequently in sufficient amount to change the type, since the map was made, from Peat to Black Sandy Loam.

FIG. 5.—ONION HARVEST ON DEEP PEAT

Management.—The water table is high in most of the Deep Peat areas. Drainage is secured by means of dredge ditches. Some of this land is used for trucking and is good for this purpose. It often contains sufficient alkali to be harmful and requires the use of potash. Some experiments on Deep Peat on a field located at Manito are described on page 64.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items, such as native vegetation (whether timber or prairie), topography, and geological origin and formation, may assist in the differentiation of types, altho they are not fundamental to it.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a matured soil, three horizons designated as *A*, *B*, and *C* are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the *A* horizon.

C designates the layer lying below the *B* horizon and in which the material has been less affected by the weathering processes.

Frequently differences within a stratum or zone are discernible, in which case it is subdivided and described under such designations as A_1, and A_2, B_1, and B_2, etc.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in differentiating soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of this report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their respective index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation

1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* formed by material derived from the Illinoisan or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan.

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the remainder of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinois glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors..

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to the last of November. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction.

FIG. 6.—EXAMINING THE SOIL PROFILE

Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 7.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, crop-

ping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed

FIG. 7.—ALL ESSENTIAL PLANT-FOOD ELEMENTS MUST BE PRESENT

The jars in which these corn plants are growing contain pure sand to which have been added various combinations of the essential plant-food elements. If a single one of these elements is omitted, the plants cannot develop; they die after the small supply stored in the seed becomes exhausted.

from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5.
[2]Young second-year growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4, have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

FIG. 8.—LEGUMES CAN OBTAIN THEIR NITROGEN FROM THE AIR

The photograph tells the story of how clover benefits the soil. In the pot at the left all the essential plant-food elements, including nitrogen, are supplied. In the middle jar all the elements, with the single exception of nitrogen, are present. At the right nitrogen is likewise withheld but the proper bacteria are supplied which enable the clover to secure nitrogen from the air.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorous to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorous, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogeneous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, acid phosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate, and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years,

about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorous from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium, sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorous or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with

and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorous, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average livestock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phophorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface $6\frac{2}{3}$ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton;

while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop be corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the best adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)
Sixth year —Clover, or clover and grass

In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed; or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

The two following rotations are suggested as especially adapted for combating the corn borer:

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Corn (for silage)
Sixth year —Wheat (with sweet clover)

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Wheat (with alfalfa)
Sixth year —Alfalfa

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)
Fifth year —Clover

First year —Corn
Second year —Soybeans
Third year —Corn
Fourth year —Wheat, (with legume)
Fifth year —Legume

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field rotating over all fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute barley or rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover, or it may include alfalfa used as a biennial. The mixing of alfalfa with clover seed for a legume crop is a recommendable practice. In connection with livestock production it may be desirable to mix grass with the clover for pasture or hay. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to Those Occurring in Henry County)

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on varions types of soil. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the results from certain of these fields located on types of soil described in the foregoing part of this soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system. Some modifications have been introduced in recent years.

Definite Crop Rotations Followed

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residue system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated (aP=acid phosphate, bP=bonemeal, rP=rock phosphate, sP=slag phosphate)
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
Le = Legume used as green manure
Cv = Cover crop
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed
| = Heavy vertical rule, indicating the beginning of complete treatment
|| = Double vertical rule, indicating a radical change in the cropping system

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

THE MT. MORRIS FIELD

The Mt. Morris experiment field was established in 1910 at Mt. Morris in Ogle county. The soil represents fairly well the type Light Brown Silt Loam, altho the plots are not altogether uniform in this respect. The plots considered here comprize four series under a rotation of corn, oats, clover, and wheat, with soil treatments as indicated in the accompanying table. The application of straw to the residues plots has been discontinued in these later years. In 1922 the application of limestone, and in 1923 the application of rock phosphate, were indefinitely suspended in order to observe the residual effect of these materials.

TABLE 7.—MT. MORRIS FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1913-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *14 crops*	Oats *14 crops*	Wheat *12 crops*	Clover[1] *10 crops*	Soybeans *2 crops*
1	0	45.3	58.5	23.3	(1.96)	(1.56)
2	M	59.5	67.4	28.1	(2.53)	(1.70)
3	ML	64.4	70.5	34.4	(2.97)	(1.80)
4	MLP	64.3	71.5	35.9	(2.92)	(1.92)
5	0	44.6	54.9	23.5	(1.61)	13.5
6	R	51.2	59.4	25.8	(1.77)	16.0
7	RL	62.2	68.8	32.7	(2.24)	18.9
8	RLP	65.6	70.2	36.2	(2.23)	20.7
9	RLPK	67.2	70.4	36.3	(2.24)	20.0
10	0	43.6	52.4	24.6	(1.79)	(1.68)
	Crop Increases					
	M over 0	14.2	8.9	4.8	(.57)	(.14)
	R over 0	6.6	4.5	2.3	(.16)	2.5
	ML over M	4.9	3.1	6.3	(.44)	(.10)
	RL over R	11.0	9.4	6.9	(.47)	2.9
	MLP over ML	— .1	1.0	1.5	—(.05)	(.12)
	RLP over RL	3.4	1.4	3.5	—(.01)	1.8
	RLPK over RLP	1.6	.2	.1	(.01)	— .7

[1]Some clover seed is evaluated as hay.

A summary of the results of the work is given in Table 7, in the form of the average annual crop yields for the years since the complete soil treatments have been in effect.

FIG. 9.—CORN ON THE MT. MORRIS FIELD

The two pictures represent the extremes in corn production according to soil treatment. Where the untreated land has produced as a fourteen-year average 44.6 bushels an acre, the land under the residues, limestone, phosphate, potash treatment has yielded 67.2 bushels. The most profitable treatment on this field, however, has been that of residues and limestone, which has produced 62.2 bushels an acre.

In looking over these results, one may observe first the beneficial effect of farm manure (M). The annual crop increases due to the use of manure alone amount to over 14 bushels an acre for corn, nearly 9 bushels of oats, almost 5 bushels of wheat, and about ½ ton of clover. Organic manure furnished by "residues" (R) has likewise proved beneficial to all crops, but not in the same degree as stable manure.

Limestone (L) in addition to organic manures has been used with good effect, the improvement being especially marked in the residues system.

Rock phosphate (P) has produced no significant effect applied with manure and limestone. In the corresponding residues system the increases in yield obtained from rock phosphate are somewhat larger, but they have not been sufficient to cover the cost of the phosphate applied.

Potassium (K), in the combination used in these experiments, has produced no results of significance.

THE KEWANEE FIELD

A University soils experiment field is located in Henry county about midway between Kewanee and Galva. This field has been in operation since 1915. It includes 20 acres of the dark-colored loessial soil characteristic of the region. The main soil type represented is Brown Silt Loam, altho a detailed examination reveals the presence of a second type occupying the basin of the draw which traverses the field in a winding direction. This minor type is classified as Black Clay Loam On Drab Clay. The distribution of these soil types, as well as the arrangement of plots, is charted in the accompanying diagram (Fig. 10). The topography of the land is also represented in the diagram by contour lines. As

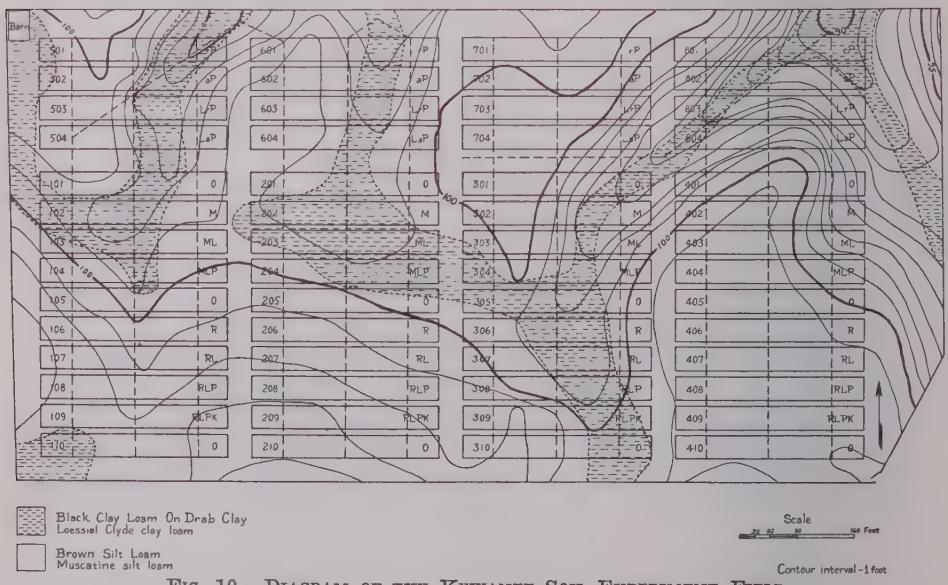


FIG. 10.—DIAGRAM OF THE KEWANEE SOIL EXPERIMENT FIELD

This diagram shows the arrangement of plots, the soil treatments applied, the location of the two soil types and, by means of contour lines, the natural drainage of the field.

these lines indicate, the land is rather rolling and it has a tendency to wash at certain spots. A thoro system of tiling has been installed on the field and the drainage is fairly satisfactory. The field is laid out in two systems of plots, each system under a separate program of crop rotation.

The 100, 200, 300, and 400 Series

The four series of plots designated as series 100, 200, 300, and 400 are each made up of 10 fifth-acre plots under the different soil treatments indicated in the accompanying tables and diagram. A rotation system of wheat, corn, oats, and clover has been practiced, the crops being managed mainly as described on page 45. Since 1921 the clover on the residues plots has been harvested for hay instead of seed and the oat straw has not been returned to the land. Since 1922 the periodic application of limestone has been suspended until it shall be needed again, and the practice of returning the wheat straw has been discontinued.

Since the Kewanee field is located in Henry county, a complete record of the yields of all crops grown is included in this report. Table 8 contains the crop yields for Series 100, 200, 300, and 400, and Table 9 gives a summary of the results showing the average annual yields for the different kinds of crops, including the years since the complete soil treatments have been in effect.

In looking over these results one may observe first the effect of animal manure (M), which has given profitable increases in all the crops. Residues alone (R), however, show no significant effect.

Limestone (L) in addition to manure has resulted in a little improvement, probably sufficient to cover the cost. It has been somewhat more effective in the grain system than in the livestock system.

Phosphorus (P), as usual, shows up in these averages to best advantage on the wheat crop in the residues system. Where used with manure and limestone, little effect was produced except on the wheat; but where used with residues and limestone, fair increases were produced in all crops, sufficient to return a financial profit under present market conditions. A detailed study of the data reveals a fact of interest in this connection which the averages do not bring out, and that is that the phosphate exerted very little influence during the earlier years of the experiments. Within the past six or seven years, however, the phosphorus treatment has come suddenly into evidence and the trend of its effectiveness seems at present to be on the upgrade.

No significant response appears as the result of potassium fertilization (K), thus indicating the futility of purchasing potassium fertilizer for use in this kind of a cropping system on this kind of soil.

The 500, 600, 700, and 800 Series

The short series (Nos. 500, 600, 700, and 800) have but 4 plots each and they constitute the so-called minor system of plots. They are now given over to a comparison of the effectiveness of rock phosphate and acid phosphate.

Alfalfa was grown on these plots until 1922. In the beginning, limestone was applied to Plots 3 and 4 at the rate of 4 tons an acre. This application was repeated in 1919. In 1922 the present experiments with phosphates were begun

TABLE 8.—KEWANEE FIELD: SERIES 100, 200, 300, 400
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1915 Corn[1]	1916 Oats[2]	1917 Clover[4]	1918 Wheat[4]	1919 Corn	1920 Oats	1921 Clover	1922 Wheat	1923 Corn	1924 Oats	1925 Clover	1926 Wheat	1927 Corn
101	0	32.6	66.4	(1.67)	13.1	55.8	62.7	(1.83)	34.8	35.0	80.0	(.97)	32.5	39.0
102	M	40.5	68.4	(2.33)	34.6	66.3	65.8	(2.48)	31.7	54.8	93.3	(1.54)	43.6	66.6
103	ML	37.3	68.3	(2.04)	26.7	69.3	74.7	(2.19)	36.6	51.5	98.9	(1.51)	49.2	67.4
104	MLP	37.5	63.6	(1.70)	32.5	67.5	75.6	(2.16)	41.0	50.8	99.7	(1.61)	56.6	73.4
105	0	38.6	69.8	.42	34.1	65.1	67.0	(1.96)	36.7	38.8	84.1	(1.31)	37.8	41.2
106	R	32.4	63.3	.54	41.0	52.4	63.0	(2.11)	39.2	49.1	80.0	(.60)	43.6	44.8
107	RL	44.2	62.3	.67	40.1	71.5	64.5	(2.04)	35.3	53.3	94.5	(.79)	53.2	53.4
108	RLP	36.3	68.1	.79	46.0	77.2	67.5	(2.58)	39.1	58.3	100.6	(1.00)	60.2	63.6
109	RLPK	41.6	64.7	.58	50.8	71.1	70.0	(2.87)	40.5	61.4	97.7	(1.05)	60.4	68.8
110	0	44.2	63.4	(1.85)	40.5	47.8	56.2	(2.50)	39.9	48.8	79.4	(1.79)	26.5	37.2
		Wheat[1]	Corn[3]	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat
201	0	33.8	42.7	72.0	(2.76)	30.1	58.1	43.9	(2.32)	29.1	51.5	55.0	(0.00)	28.2
202	M	35.0	43.7	84.4	(2.95)	27.0	65.3	53.4	(2.96)	33.7	62.0	75.8	(1.40)	38.3
203	ML	36.5	50.6	95.2	(3.07)	28.4	69.6	52.0	(3.03)	36.5	63.2	76.4	(1.79)	35.5
204	MLP	29.9	46.0	82.7	(3.35)	28.0	72.4	52.8	(3.10)	38.9	64.2	69.7	(1.39)	41.2
205	0	30.8	46.3	72.3	(1.46) .42	35.1	60.8	47.3	(2.49)	30.3	50.0	50.9	(0.00)	34.8
206	R	41.2	47.9	70.5	(1.22) .38	31.8	51.9	44.5	(2.81)	31.2	53.0	58.4	(.64)	34.9
207	RL	27.2	52.5	68.6	(1.60) .25	25.4	61.4	45.0	(2.82)	30.8	56.0	63.6	(1.13)	37.1
208	RLP	29.7	49.2	71.2	(1.67) .12	26.8	64.7	47.5	(2.94)	38.4	62.4	74.7	(1.45)	43.9
209	RLPK	28.8	54.2	77.3	(1.82) .17	28.4	68.9	46.7	(2.94)	42.2	62.1	73.9	(1.70)	46.2
210	0	31.7	45.6	67.8	(2.10)	31.8	41.0	41.4	(1.58)	24.8	45.0	49.1	(0.00)	27.0

[1]Limestone only. [2]No manure or potassium. [3]No potassium. [4]No manure.

TABLE 8.—*Concluded*

Bushels or (tons) per acre

Plot No.	Soil treatment applied	1915 Soybeans[1]	1916 Wheat[2]	1917 Corn	1918 Oats	1919 Clover	1920 Wheat	1921 Corn	1922 Oats	1923 Clover	1924 Wheat	1925 Corn	1926 Oats	1927 Clover
301	0	19.7	17.8	47.5	59.7	(1.93)	28.3	72.6	61.7	(.87)	38.3	56.8	62.5	(1.61)
302	M	(1.78)	13.6	49.2	65.2	(1.98)	31.2	74.5	69.7	(1.49)	40.8	70.8	74.1	(2.33)
303	ML	(1.62)	10.1	56.2	67.8	(1.81)	29.3	84.2	71.6	(1.99)	46.9	73.0	74.7	(2.64)
304	MLP	(1.70)	15.5	58.5	65.2	(2.06)	35.3	78.7	72.3	(1.85)	49.4	80.4	76.9	(3.56)
305	0	20.2	12.8	44.1	55.0	(1.84)	27.2	66.2	62.0	(.54)	33.4	59.1	57.8	(2.11)
306	R	19.1	13.7	39.9	62.0	(1.16)	29.2	74.9	54.4	(.85)	35.2	61.8	52.5	(1.17)
307	RL	19.6	10.2	47.0	59.1	(1.17)	29.4	78.6	63.9	(1.31)	43.6	68.0	54.4	(1.29)
308	RLP	19.7	14.3	51.0	67.0	(1.43)	38.4	78.3	58.8	(1.71)	49.1	82.6	73.9	(1.79)
309	RLPK	22.2	16.4	57.6	70.6	(1.54)	35.9	90.3	66.9	(1.70)	49.8	77.7	79.1	(1.66)
310	0	19.7	14.8	44.0	62.5	(1.85)	31.1	69.9	50.6	(0.00)	31.0	56.2	62.2	(0.00)
		Oats[1]	Clover[3]	Wheat[5]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats
401	0	83.8	(2.43)	26.5	60.5	36.1	(.84)	25.3	52.0	54.2	(3.31)	23.4	64.2	65.8
402	M	80.0	(2.34)	27.5	66.8	43.6	(1.36)	32.0	69.0	69.4	(4.14)	24.0	69.8	78.8
403	ML	91.6	(2.51)	27.3	68.4	48.4	(1.42)	35.7	78.6	61.6	(3.53)	24.4	73.8	81.7
404	MLP	77.0	(2.04)	26.1	70.2	45.5	(1.59)	39.9	78.8	67.2	(3.89)	35.9	75.2	81.7
405	0	84.8	(4)	30.2	58.0	43.3	(.80) .29	30.6	57.5	56.4	(2.82)	20.1	58.6	70.9
406	R	77.5	(4)	34.8	69.8	43.6	(.83) .40	30.8	64.4	51.3	(3.31)	23.4	61.8	70.5
407	RL	88.1	(4)	32.0	76.8	44.1	(1.00) .40	33.8	81.3	63.9	(4.04)	29.2	66.8	70.8
408	RLP	87.8	(4)	33.2	69.4	45.3	(.89) .35	36.7	89.0	69.4	(3.91)	35.9	68.2	74.8
409	RLPK	95.6	(4)	38.7	75.7	46.4	(.81) .19	32.6	86.6	64.4	(3.90)	35.0	82.6	78.3
410	0	72.2	(1.95)	19.7	53.2	35.2	(1.03)	24.7	54.9	49.1	(2.96)	27.4	48.8	57.8

[1]Limestone only. [2]No manure or potassium. [3]Lime and residues only. [4]No seed harvested in 1916. [5]No manure.

FIG. 11.—A LESSON IN SOIL MANAGEMENT ON THE KEWANEE FIELD
Field meetings are held from time to time which are attended by farmers and others interested in soil improvement. The lessons from the plots themselves are supplemented by exhibits arranged to bring out important principles of soil fertility.

and the same rotation practiced on the larger series was established on these series. In this phosphate comparison rock phosphate is used on Plots 1 and 3 at the annual rate of 400 pounds an acre, applied once in the rotation ahead of the wheat, but beginning with 1927 rock phosophate has been applied at the same time as the acid phosphate. Acid phosphate is used on Plots 2 and 4 at the annual rate of 200 pounds an acre. It is applied twice in the rotation, one-half for wheat and one-half for oats.

TABLE 9.—KEWANEE FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1917-1927—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *9 crops*	Corn *11 crops*	Oats *11 crops*	Clover[1] *10 crops*
1	0	30.0	53.9	59.4	(1.64)
2	M	33.6	65.0	70.3	(2.26)
3	ML	35.8	68.7	73.0	(2.30)
4	MLP	40.7	70.0	71.2	(2.46)
5	0	31.8	54.5	60.6	(1.60)
6	R	33.3	56.7	59.2	(1.55)
7	RL	35.3	64.9	61.9	(1.78)
8	RLP	40.9	69.5	68.2	(1.98)
9	RLPK	41.2	73.0	70.1	(2.03)
10	0	29.4	49.7	56.6	(1.38)
	Crop Increases				
	M over 0	3.6	11.1	10.9	(.62)
	R over 0	1.5	2.2	− 1.4	−(.05)
	ML over M	2.2	3.7	2.7	(.04)
	RL over R	2.0	8.2	2.7	(.23)
	MLP over ML	4.9	1.3	− 1.8	(.16)
	RLP over RL	5.6	4.6	6.3	(.20)
	RLPK over RLP	.3	3.5	1.9	(.05)

[1]Some clover seed is evaluated as hay.

TABLE 10.—KEWANEE FIELD: SERIES 500, 600, 700, 800
Annual Crop Yields—Bushels or (tens) per acre

Plot No.	Soil treatment applied	1915 Barley	1916 Alfalfa seeding	1917 Alfalfa seeding	1918 Alfalfa seeding	1919 Alfalfa	1920 Alfalfa	1921 Corn	Soil treatment applied	1922 Wheat	1923 Corn	1924 Oats	1925 Clover	1926 Wheat	1927 Corn
501	0	19.2	....	....	....	(2.65)	(2.26)	70.7	Le rP	34.5	70.1	88.8	(2.22)	56.0	58.3
502	0	26.1	....	....	....	(2.38)	(2.40)	63.9	Le aP	38.9	68.2	90.9	(1.88)	54.4	59.1
503	L	18.2	....	....	....	(2.15)	(2.41)	71.7	LeLrP	31.8	69.7	90.6	(1.87)	51.5	56.0
504	L	23.7	....	....	....	(2.37)	(2.54)	70.0	LeLaP	40.5	66.1	98.1	(2.08)	55.7	56.5
		Barley	Alfalfa seeding	Alfalfa seeding	Alfalfa seeding	Alfalfa	Alfalfa	Alfalfa		Alfalfa	Wheat	Corn	Oats	Clover	Wheat
601	0	25.7	....	....	....	(2.48)	(2.47)	(4.57)	Le rP	(4.94)	36.4[1]	67.6	84.8	(2.29)	45.6
602	0	25.6	....	....	....	(2.47)	(2.60)	(4.32)	Le aP	(5.05)	41.4	70.2	80.0	(2.45)	46.4
603	L	22.7	....	....	....	(3.05)	(2.78)	(4.18)	LeLrP	(4.83)	33.1	70.9	70.3	(2.33)	41.7
604	L	20.2	....	....	....	(2.20)	(2.21)	(3.66)	LeLaP	(4.85)	40.1	69.1	64.8	(2.31)	46.2
		Barley	Alfalfa seeding	Alfalfa seeding	Alfalfa seeding	Alfalfa	Alfalfa	Alfalfa		Oats	Clover	Wheat	Corn	Oats	Clover
701	0	29.2	....	....	....	(2.85)	(2.61)	(4.63)	Le rP	57.5	(3.81)	50.7	80.1	80.6	(3.71)
702	0	23.8	....	....	....	(2.83)	(2.49)	(4.50)	Le aP	62.2	(4.10)	55.6	81.4	82.8	(3.69)
703	L	22.4	....	....	....	(3.80)	(3.01)	(4.36)	LeLrP	57.5	(4.07)	48.9	74.8	79.2	(3.51)
704	L	30.9	....	....	....	(2.89)	(2.58)	(3.94)	LeLaP	63.6	(3.86)	58.3	79.7	80.5	(3.47)
		Barley	Alfalfa seeding	Alfalfa seeding	Alfalfa seeding	Alfalfa	Alfalfa	Alfalfa		Corn	Oats	Clover	Wheat	Corn	Oats
801	0	25.1	....	....	....	(2.57)	(1.99)	(3.72)	Le rP	78.9	61.1	(4.03)	44.9	75.4	80.6
802	0	22.1	....	....	....	(2.25)	(1.91)	(3.72)	Le aP	75.8	72.2	(3.45)	46.0	70.6	82.2
803	L	14.7	....	....	....	(2.29)	(2.30)	(3.78)	LeLrP	77.7	67.5	(3.51)	37.4	65.8	81.1
804	L	21.8	....	....	....	(2.47)	(2.31)	(3.79)	LeLaP	80.4	68.6	(3.92)	45.7	70.0	84.7

[1]Wheat damaged by standing water in 1923.

Table 10 provides an outline of the crop history of these plots and a summary of the annual crop yields is given in Table 11.

TABLE 11.—KEWANEE FIELD: PHOSPHATE EXPERIMENT

Average Annual Crop Yields and Corresponding Money Values, 1922-1927
Bushels or (tons) per acre

Soil treatment	Wheat *6 crops*	Corn *6 crops*	Oats *6 crops*	Hay *6 crops*	Value per acre[1]
Rock phosphate	44.7	71.7	75.6	(3.50)	$45.41
Acid phosphate	47.1	70.9	78.4	(3.44)	46.06
Limestone, rock phosphate	40.7	69.1	74.4	(3.52)	43.72
Limestone, acid phosphate	47.8	70.3	76.7	(3.61)	46.60

[1]With wheat at $1.20 a bushel, corn at 68 cents, oats at 40 cents, and hay at $14 a ton, which are the average December 1 quotations for the last six years. The cost of the two phosphorus carriers are estimated at $12 a ton for the rock and $24 a ton for the acid, thus making the expense for the two kinds equal.

The difficulty in arriving at a final conclusion regarding the comparative economy in the use of these different phosphorous materials is obvious, for all depends upon their relative cost, which fluctuates from time to time. Furthermore the prices received from farm produce likewise fluctuate; and to complicate matters still further, these fluctuations do not necessarily run parallel with those of the fertilizer cost. However, one may readily compute for himself the relative economy of producing these crop increases by applying any set of prices for crops and fertilizers which appear to be most applicable according to prevailing market conditions. For this purpose the following set of prices are assumed as representing the average market conditions for the past 6 years (December 1 quotations): wheat, $1.20 a bushel; corn, 68 cents; oats, 40 cents; and hay, $14 a ton. For the cost of the two phosphorus carriers, an estimate of $12 a ton for rock phosphate and $24 a ton for acid phosphate may be taken, thus making the expense for the two kinds of phosphate equal.

When these prices are applied to the yields given in Table 11, the acid phosphate plot with limestone shows the highest average annual gross return, $46.60. The limestone, however, appears to be responsible for only 54 cents of this amount, thus indicating that the purchase of limestone for this combination was unprofitable. The returns from rock phosphate with limestone were $1.69 an acre less than those from rock phosphate alone. Thus, of the treatments included in this test, the most profitable lies in one of the two forms of phosphates used alone, and the results thus far show a gross return of 65 cents per acre in favor of the acid phosphate. It is of interest to note that wheat has been the crop most affected by the form of phosphate applied. It is to be borne in mind that the order of values can easily be shifted by a change in the relative yields of the respective crops or by a change in commodity prices. Furthermore no consideration has been given here to any possible difference in the residual effects of the two forms of phosphate which might appear upon discontinuing the treatments.

THE ALEDO FIELD

An experiment field representing the soil type Brown Silt Loam On Clay is located in Mercer county just west of Aledo. This field has been in operation since 1910. From its physical aspects this field should be well adapted to experimental work, the land being unusually uniform in topography and in soil profile.

There are two general systems of plots and they are designated as the major and the minor systems. The major system comprizes four series (numbered 100, 200, 300, 400) made up of 10 plots each. The plots were handled substantially as described for standard treatment until 1918, when it was planned to harvest the first crop of red clover on the residues plots for hay and to plow down the second crop if no seed were formed. In 1921 the return of the oat straw was discontinued. In 1923 the rotation was changed to one of corn, corn, oats, and wheat. In this rotation it was planned to seed hubam clover in the oats on all plots, for use as hay or for soil improvement, and common sweet clover in the wheat on the residues plots for use as a green manure. Since this change, no residues except cornstalks and the green manure have been returned to the residues plots. The limestone applications were temporarily abandoned in 1923. No more will be applied until a need for lime appears. The phosphate applications were evened up to a total of 4 tons an acre in 1924, and no more will be applied for some time at least.

Table 12 gives a summary of the results, showing the average annual yields obtained for the period beginning when complete soil treatment came into sway. The lower section of the table, which gives comparisons in terms of crop increases, is intended to indicate the effect of the different fertilizing materials applied.

TABLE 12.—ALEDO FIELD: GENERAL SUMMARY OF CROP YIELDS
Average Annual Crop Yields 1912-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *12 crops*	Corn *19 crops*	Oats *14 crops*	Clover[1] *6 crops*	Soybeans *3 crops*
1	0	30.1	57.2	57.9	(2.21)	(1.60)
2	M	34.5	71.1	64.5	(2.74)	(1.63)
3	ML	34.6	74.3	67.6	(3.12)	(1.60)
4	MLP	36.6	75.6	68.2	(3.05)	(1.61)
5	0	30.8	60.1	59.7	(2.00)	16.1
6	R	31.4	66.5	61.2	(1.91)	16.5
7	RL	33.5	71.9	66.5	(1.96)	18.8
8	RLP	38.0	74.4	68.0	(2.08)	20.3
9	RLPK	37.3	76.0	70.3	(1.73)	20.9
10	0	30.1	58.3	58.1	(2.38)	(1.62)
	Crop Increases					
	M over 0	4.4	13.9	6.6	(.53)	(.03)
	R over 0	.6	6.4	1.5	−(.09)	.4
	ML over M	.1	3.2	3.1	(.38)	−(.03)
	RL over R	2.1	5.4	5.3	(.05)	2.3
	MLP over ML	2.0	1.3	.6	−(.07)	(.01)
	RLP over RL	4.5	2.5	1.5	(.12)	1.5
	RLPK over RLP	− .7	1.6	2.3	−(.35)	.6

[1]Some clover seed is evaluated as hay.

In looking over these results we may observe first the beneficial effect of animal manure (M) on all crops but especially on corn. This suggests the advisability of carefully conserving and regularly applying all stable manure. Residues (R) alone have been beneficial for corn but have shown little effect on the other crops of the rotation.

Where limestone (L) has been applied, there is usually a small increase in average yields, the increase becoming particularly marked in the corn crop in the residues system.

The addition of rock phosphate (P) to the treatment has had very little effect in the manure system. Somewhat more favorable are the results in the residues system, so that under average market conditions there has been some margin of profit from the use of rock phosphate applied in the manner of these experiments. However, the economic story has not all been told, for the application of lime and phosphate has been discontinued in order to observe the residual effects. The results of the next few years therefore, will be awaited with great interest.

For the effect of potassium treatment (K), we may compare Plots 8 and 9. No significant response appears from this treatment so far as these common field crops show.

A number of problems have arisen out of the experience on this and other experiment fields which call for some revision of the investigations described above, and accordingly certain changes have been made in the conduct of these plots which are intended especially to throw more light upon the problems of liming and applying phosphorus. (See Soil Report No. 29, Mercer County Soils).

Experiments on the Minor Series

The so-called minor system of plots (Series 500, 600, 700, 800) on the Aledo field is given over to a comparison of the effectiveness of different carriers of phosphorus.

In this experiment each series contains four plots. Plot 1 receives residues treatment only; Plot 2 receives residues and phosphorus in one of the forms under test; Plot 3 receives residues, limestone, and phosphorus; and Plot 4 is similar to Plot 3 with phosphorus omitted. On one series steamed bone meal (bP) is used as the carrier of phosphorus and is applied at the rate of 200 pounds per acre per year. On another series acid phosphate (aP) is applied at the yearly rate of 333⅓ pounds per acre. On a third series rock phosphate (rP) serves as the source of phosphorus and is applied at the rate of 666⅔ pounds per acre yearly. On the last series basic slag phosphate (sP) is applied at the rate of 250 pounds per acre yearly.

The yields for all crops harvested on these plots are recorded in Table 13. Table 14, which is derived from Table 13, shows differences in crop yields presumed to have resulted from applying the various forms of phosphatic fertilizers for the eleven crops harvested since the beginning of the applications up to 1926. In computing these comparisons, each phosphate plot is compared with its neighboring non-phosphate plot. Aside from the soybeans, the figures show without exception more or less crop increase on the phosphorus plots, no matter what the form of carrier employed.

TABLE 13.—ALEDO FIELD: PHOSPHATE EXPERIMENT
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied[1]	1916[2] Corn	1917[2] Oats	1918[2] Soy-beans	1919 Wheat	1920 Corn	1921 Oats	1922 Clover hay	1923 Corn	1924 Corn	1925 Oats	1926 Wheat
501	R	53.4	85.5	18.9	32.4	72.8	48.9	(2.88)	83.5	58.2	63.9	44.0
502	RbP	61.7	91.7	19.0	34.7	86.4	61.9	(3.25)	82.7	66.0	75.0	59.2
503	RLbP	61.5	90.6	23.2	35.6	87.3	53.3	(3.48)	82.5	66.8	73.4	62.0
504	RL	55.1	80.5	22.6	32.9	77.7	47.7	(2.61)	88.2	60.3	64.5	44.6
601	R	55.2	84.7	19.5	33.0	71.2	53.6	(3.17)	84.7	57.3	64.4	43.3
602	RaP	57.8	87.7	18.7	38.3	87.1	60.9	(3.23)	82.5	65.9	76.1	60.6
603	RLaP	64.7	83.4	23.1	38.2	88.1	52.3	(3.53)	77.6	64.7	78.1	64.4
604	RL	51.9	81.7	24.6	32.8	84.9	50.2	(3.06)	84.1	51.9	64.1	47.3
701	R	54.3	83.1	20.8	34.2	75.6	52.8	(3.41)	82.8	61.2	66.6	44.8
702	RrP	58.8	83.3	23.3	36.7	80.4	63.0	(3.60)	87.8	69.3	70.3	59.2
703	RLrP	57.2	81.2	28.1	36.7	80.2	53.3	(3.82)	86.6	70.8	67.8	57.5
704	RL	52.1	81.7	26.9	34.1	82.0	48.9	(3.15)	84.6	62.5	66.3	48.8
801	R	57.6	73.8	18.0	33.7	68.1	54.8	(2.62)	74.3	58.8	45.0	45.8
802	RsP	56.4	87.8	20.6	38.1	81.0	66.2	(3.66)	80.0	69.1	66.3	60.2
803	RLsP	53.3	78.9	23.7	38.4	83.6	57.0	(3.63)	82.0	70.2	66.7	66.0
804	RL	51.8	77.5	21.8	33.3	70.4	59.8	(2.99)	82.6	59.9	53.9	48.2

[1]Bone meal (bP) at the rate of 200 pounds per acre per year. Acid phosphate (aP) at the rate of 333⅓ pounds per acre per year. Rock phosphate (rP) at the rate of 666⅔ pounds per acre per year. Slag phophate (sP) at the rate of 250 pounds per acre per year. All minerals applied once in the rotation ahead of the wheat crop.

[2]No residues.

Attention has already been called to the difficulties in making exact comparisons of this nature, on account of the fluctuation in prices of both farm products and fertilizer materials. A set of arbitrary prices, as indicated in the

TABLE 14.—ALEDO FIELD: AVERAGE ANNUAL CROP INCREASES PER ACRE AND THEIR VALUE PRODUCED BY THE VARIOUS FORMS OF PHOSPHATE
Computed from Yields in Table 13—Bushels or (tons) per acre

Comparison of treatments	Wheat *2 crops*	Corn *4 crops*	Oats *3 crops*	Clover *1 crop*	Soy-beans *1 crop*	Value of increase *11 crops*[1]	Cost of phos-phate *11 years*[2]	Profit from *11 crops*	Profit per acre per year
Bone meal, residues, *over* residues	8.8	7.2	10.1	(.37)	.1	$62.93	$44.00	$18.93	$1.72
Bone meal, residues, lime, *over*, residues, lime	11.0	4.2	8.2	(.87)	.6	65.12	44.00	21.12	1.92
Acid phosphate, residues *over* residues	11.3	6.2	7.3	(.06)	— .8	56.41	44.00	12.41	1.13
Acid phosphate, residues, lime, *over* residues, lime	11.3	5.6	6.0	(.47)	—1.5	57.95	44.00	13.95	1.27
Rock phosphate, residues, *over* residues	8.5	5.6	4.7	(.19)	2.5	51.00	44.00	7.00	.64
Rock phosphate, residues, lime, *over* residues, lime	5.7	3.4	1.8	(.67)	1.2	38.73	44.00	—5.27	— .48
Slag phosphate, residues, *over* residues	9.3	6.9	15.4	(1.04)	2.6	84.24	27.50	56.74	5.16
Slag phosphate, residues, lime, *over* residues, lime	11.4	6.1	3.8	(.64)	1.9	64.38	27.50	36.88	3.35

[1]With wheat at $1.25 a bushel, corn at 75 cents, oats at 45 cents, soybeans at $1.50, and clover at $15 a ton; which values, with the exception of that for soybeans, are all under the average December 1 farm price quotations for the eleven years in which these crops were produced. No official quotations were found for soybeans.

[2]The cost of the phosphatic materials is estimated as follows: bone meal $40 a ton, acid phosphate $24, rock phosphate $12, and slag phosphate $20.

footnote to Table 14, may therefore be assumed as representing approximately average market conditions. The values for the phosphatic fertilizers would seem conservative enough, and furthermore the quantities of these materials employed in these experiments are, with the possible exception of the slag phosphate, greater than ordinarily would be used, or need to be used, in good farm practice.

Reckoned on the basis of the prices shown, slag phosphate appears to have produced the most profitable returns of the four phosphorus carriers in the test, bringing an average profit of $5.16 an acre yearly where applied without limestone and $3.35 where applied with limestone. Bone meal has given an average profit of $1.72 applied without limestone and $1.92 applied with limestone. Acid phosphate has returned $1.13 used without limestone and $1.27 used with limestone. Rock phosphate has produced the lowest money returns, giving a profit of 64 cents an acre a year when applied without limestone and a loss of 48 cents when used with limestone.

No consideration is given in these comparisons to the relative phosphorus reserves which should have accumulated in the soil, and it should be emphasized again that the order of these values might be easily shifted by relatively small change in commodity prices.

The results from the limestone treatments on the plots of this minor series are shown in Table 15. This material was applied to Plots 3 and 4 in 1912, when the land was still under alfalfa, at the rate of 4 tons an acre, and another dressing was added in 1917, after the present experiments were under way.

Comparing first the results from the check plots, which receive no phosphorus, it appears that limestone used with residues alone has been of doubtful benefit to all crops excepting soybeans.

TABLE 15.—ALEDO FIELD: AVERAGE ANNUAL CROP INCREASES PER ACRE AND THEIR VALUE PRODUCED BY LIMESTONE

Computed from Yields in Table 13—Bushels or (tons) per acre

Comparison of treatments	Wheat *2 crops*	Corn *4 crops*	Oats *3 crops*	Clover *1 crop*	Soybeans *1 crop*	Value of increase *11 crops*[1]	Cost of limestone *11 years*[2]	Profit from *11 crops*	Profit per acre per year
Limestone, residues, *over* residues	1.4	2.0	− .1	−(.07)	4.7	$15.36	$12.00	$3.36	$ .31
Limestone, residues, bone meal, *over* residues, bone meal	2.8	.3	−3.8	(.23)	4.2	12.52	12.00	.52	.05
Limestone, residues, acid phosphate, *over* residues, acid phosphate	1.9	.5	−3.6	(.30)	4.4	12.49	12.00	.49	.04
Limestone, residues, rock phosphate, *over* residues, rock phosphate	− .9	− .4	−4.8	(.22)	4.8	.57	12.00	−11.43	−1.04
Limestone, residues, slag phosphate, *over* residues, slag phosphate	3.1	.7	−5.8	−(.03)	3.1	6.22	12.00	− 5.78	− .53

[1]For crop values used in these computations, see footnotes to Table 14.

[2]A charge of $2 a ton is made for the six tons of limestone applied.

Considering all treatments, the soybeans exhibit a consistent gain from limestone, while oats respond with a consistent loss. At the prices for crops and limestone assumed in these computations, a profit of 31 cents an acre a year for limestone applied without phosphate of any kind is found. Where limestone was applied with bonemeal, the limestone profit was 5 cents an acre a year, and with acid phosphate it was 4 cents. Used with rock phosphate, the crop increases were so small that there was a loss of $1.04 an acre a year.

When the small margin of profit and the possible experimental error involved in this kind of work are considered, it is doubtful whether limestone used with phosphates in the manner described has, up to the present time, paid its cost. The Aledo field represents one of those borderline cases, so to speak, in which the upper soil is neutral or only slightly acid and the lime requirement, therefore, not yet very marked. As time goes on, however, and cropping continues, the need for lime will develop. It is planned to discontinue liming on these plots until its need becomes manifest, and in so doing the annual cost of the limestone already applied will become automatically reduced, so that net returns which hitherto have represented a loss may sooner or later result in a positive profit.

THE HARTSBURG FIELD

Black Clay Loam, Terrace, as noted on page 21, occupies 15 square miles in Henry county. The results of the Hartsburg field, situated in Logan county just east of the town of Hartsburg, are suggestive of the treatments that are effective on this type of soil.

TABLE 16.—HARTSBURG FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1913-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *12 crops*	Corn *19 crops*	Oats *14 crops*	Clover[2] *7 crops*	Soybeans *2 crops*	Alfalfa[1] *11 crops*
1	0	25.6	46.5	46.7	(1.84)	(1.29)	(3.47)
2	M	29.9	57.0	52.6	(2.19)	(1.64)	(3.67)
3	ML	35.0	62.9	58.0	(2.32)	(1.82)	(3.91)
4	MLP	37.2	61.8	57.5	(2.39)	(1.92)	(4.19)
5	0	30.5	52.1	46.0	(1.28)	25.8	(3.33)
6	R	33.6	62.3	54.1	(1.67)	26.8	(3.78)
7	RL	31.0	66.3	52.2	(1.64)	28.4	(3.45)
8	RLP	35.2	65.4	56.3	(1.79)	26.1	(4.04)
9	RLPK	34.6	64.3	55.4	(2.13)	26.4	(4.16)
10	0	31.1	51.6	47.4	(2.02)	(1.69)	(3.20)
	Crop Increases						
	M over 0	4.3	10.5	5.9	(.35)	(.35)	(.20)
	R over 0	3.1	10.2	8.1	(.39)	1.0	(.45)
	ML over M	5.1	5.9	5.4	(.13)	(.18)	(.24)
	RL over R	−2.6	4.0	−1.9	−(.03)	1.6	−(.33)
	MLP over ML	2.2	−1.1	− .5	(.07)	(.10)	(.28)
	RLP over RL	4.2	− .9	4.1	(.15)	− 2.3	(.59)
	RLPK over RLP	− .6	−1.1	− .9	(.34)	.3	(.12)

[1]No residues for the first six crops. [2]Some clover seed is evaluated as hay.

This field was started in 1911 and laid off in five series of 10 plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series. The program was then changed to corn, corn, oats, and wheat with sweet clover catch crop on the first series, and corn, oats, wheat, and legume hay (clover and alfalfa mixture) on the fifth series. The soil treatments are as indicated in Table 16, which summarizes by crops the yields for the period during which the plots have been under full treatment.

The outstanding feature of the results on this field is the large increases produced by organic manures whether in the form of crop residues or stable manure. The behavior of limestone (L) is rather peculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure it shows some increase in all crops, while with residues its effect on several of the crops appears negative.

Altho rock phosphate (P) has given some increases in wheat yield in both the manure and the residues systems, the results with other crops have been such as to render the use of this material unprofitable on this field. The addition of potassium (K) appears to have produced no significant effect.

It may be mentioned that new experiments have been recently started on these plots which are designed to answer some of the questions brought out by the foregoing results. For example, the effect of applying phosphorus in other carriers and in different combinations, as well as testing the residual effect of phosphate already applied, is being tried.

THE VIENNA FIELD

Henry county, as indicated in the descriptions of certain of its soil types, includes considerable land that is subject to destruction thru erosion or washing. Yellow Silt Loam, which occupies over 38 square miles in the county, is par-

FIG. 12.—PROPER SOIL AND CROPPING METHODS WOULD HAVE PREVENTED THIS CONDITION
This abandoned hillside is just over the fence from the field shown in Fig. 13. Yellow Silt Loam is particularly susceptible to this kind of damage.

ticularly susceptible to this kind of damage. Operators of this kind of land in Henry county will therefore be interested in experiments conducted on the Vienna field, in Johnson county, to test out different methods of reclaiming badly gullied land and preventing further erosion.

The Vienna field is representative of the sloping, erodible land so common in the extreme southern part of the state. When the experiments were started the whole field, with the exception of about three acres, had been abandoned because so much of the surface soil had washed away, and there were so many gullies that further cultivation was unprofitable. For the purpose of the experiments the field was divided into different sections (see Table 17). These were not entirely uniform; some parts were much more washed than others, and portions of the lower-lying land had been affected by soil material washed down from above. The higher land had a very low producing capacity; on many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except the one designated as D, which included but three plots.

Careful records were kept for nine years. The results, summarized in Table 17 indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels on the check series (D). Wheat yielded 11.1 bushels on the protected series, in comparison with 4.6 bushels on the check, and clover yielded $\frac{4}{5}$ of a ton on the protected series and but $\frac{1}{5}$ of a ton on the check.

Figs. 12 and 13 serve further to indicate what may be done with this type of soil even after it has become badly washed and gullied.

FIG. 13.—CORN GROWING ON AN IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD

This land had formerly been badly eroded. It was reclaimed by proper soil treatment and cropping. Compare with Fig. 12.

TABLE 17.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

Section A included the steepest part of the field and contained many gullies. The land was built into terraces at vertical intervals of 5 feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

Section B was used to test the so-called embankment method. Ridges were plowed up which were sufficiently high so that when there were heavy falls of rain the water would break over and run in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about 8 loads of manure an acre were turned under each year for the corn crop.

Section D was washed to about the same extent as Section C. It was farmed in the most convenient way, without any special effort to prevent washing.

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 14.—ALFALFA ON THE OQUAWKA FIELD

These pictures show the possibility of improving this unproductive sandy land of the Oquawka field. Both plots were seeded alike to alfalfa. Where manure alone was applied, the crop was a total failure, but where limestone in addition to manure was applied, nearly 4½ tons of alfalfa hay was obtained as the season's yield.

THE OQUAWKA FIELD

Since there are considerable areas of Dune Sand, Terrace, in Henry county, experiments on that type conducted by the University in Henderson county, near the Mississippi river, will be of interest. The Oquawka field was established in 1913. It is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted. Table 18 indicates the kinds of treatment applied; the amounts of the materials used were in accord with the standard practice, as explained on page 46.

Limestone (L), it will be noted, has had a remarkably beneficial action on this sand soil. Where it has been used in conjunction with crop residues, the yield of corn has been practically doubled. It has also produced good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite indifferent to treatment with rock phosphate (P). The analyses show, however, that the stock of phosphorus in this type of soil is not large; and as time goes on and the supply diminishes under the production a good-sized crops, the application of this element may become

TABLE 18.—OQUAWKA FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1915-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *12 crops*	Soybeans[1] *12 crops*	Wheat *12 crops*	Sweet clover[2] *8 crops*	Rye *10 crops*	Alfalfa *9 crops*
1	0	20.2	(.99)	8.7	0.00	12.1	(.42)
2	M	25.3	(1.19)	12.0	0.00	13.7	(.92)
3	ML	33.4	(1.61)	16.1	1.03	24.7	(2.37)
4	MLP	33.9	(1.56)	16.4	1.05	23.4	(2.45)
5	0	19.7	(.77)	10.7	0.00	12.7	(.40)
6	R	21.2	(.82)	12.2	0.00	12.9	(.45)
7	RL	37.2	(1.17)	15.1	1.41	24.0	(2.11)
8	RLP	37.0	(1.25)	15.6	1.28	24.1	(2.10)
9	RLPK	39.2	(1.20)	14.9	1.49	26.0	(2.17)
10	0	18.6	(.71)	9.6	0.00	10.3	(.29)
	Crop Increases						
	M over 0	5.1	(.20)	3.3	0.00	1.6	(.50)
	R over 0	1.5	(.05)	1.5	0.00	.2	(.05)
	ML over M	8.1	(.42)	4.1	1.03	11.0	(1.45)
	RL over R	16.0	(.35)	2.9	1.41	11.1	(1.66)
	MLP over ML	.5	−(.05)	.3	.02	− 1.3	(.08)
	RLP over RL	− .2	(.08)	.5	− .13	.1	−(.01)
	RLPK over RLP	2.2	−(.05)	− .7	.21	1.9	(.07)

[1]Eleven regular crops, together with the extra crop described in footnote 2, are averaged as 11 crops. Several crops which were harvested as seed are evaluated in this summary as hay.

[2]Some hay is evaluated as seed. In 1918 the sweet clover was killed by early cutting for a hay crop; soybeans were seeded in July, and the ensuing crop is included in the soybean average.

profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

Altho the results show an increase of about 2 bushels of corn from the use of potassium salts (K), with ordinary prices this would not be a profitable treatment. The slight increases from the use of potassium appearing in the other crops are scarcely significant.

A significant fact which the above summary does not bring out is that improvement in crop yields under favorable treatment has been progressive, as evidenced by a very marked upward trend in production after the first few years. The yield of corn, for example under the limestone-residues (RL) treatment has been 37.2 bushels an acre as an average for the 12 crops since full treatment started, but if we take an average of the last five crops, the yield rises to 42.9 bushels. Likewise the wheat yields under this same treatment for the eleven-year average is 15.1 bushels, but the average for the last five years is 22.3 bushels.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover do better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

THE MANITO FIELD

The Manito experiment field, in Mason county, which was in operation from 1902 to 1905, gives some interesting results of the effects of soil treatment on Deep Peat. There are altogether about 7½ square miles of Deep Peat in Henry county.

The field consisted of ten plots which received the treatments indicated in Table 19. Where potassium was applied, the yield was three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were used, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. However, either material furnished more potassium than was required by the crops produced.

TABLE 19.—MANITO FIELD: Deep Peat
Annual Crop Yields—Bushels per acre

Plot No.	Soil treatment 1902	Corn 1902	Corn 1903	Soil treatment 1904	Corn 1904	Corn 1905
1	None	10.9	8.1	None	17.0	12.0
2	None	10.4	10.4	Limestone, 4000 lbs	12.0	10.1
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs., kainit, 1200 lbs	49.6	47.3
4	Kainit, 600 lbs., acidulated bone, 350 lbs	30.3	33.3	Kainit, 1200 lbs., steamed bone, 395 lbs	53.5	47.6
5	Potassium chlorid, 200 lbs	31.2	33.9	Potassium chlorid, 400 lbs	48.5	52.7
6	Sodium chlorid, 700 lbs	11.1	13.1	None	24.0	22.1
7	Sodium chlorid, 700 lbs	13.3	14.5	Kainit, 1200 lbs	44.5	47.3
8	Kainit, 600 lbs	36.8	37.7	Kainit, 600 lbs	44.0	46.0
9	Kainit, 300 lbs	26.4	25.1	Kainit, 300 lbs	41.5	32.9
10	None	(1)	14.9	None	26.0	13.6

[1]Yield not recorded for 1902.

The use of 700 pounds of sodium chlorid (common salt) yielded no great increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons of ground limestone per acre produced no increase in the corn crops either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the total yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) appear to be insufficient.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1925
33 Saline, 1926
34 Marion, 1926
35 Will, 1926
36 Woodford, 1927
37 Lee, 1927
38 Ogle, 1927
39 Logan, 1927
40 Whiteside, 1928
41 Henry, 1928

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 42

MORGAN COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER,
AND L. H. SMITH

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URBANA, ILLINOIS, FEBRUARY, 1929

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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[1] Engaged in Soils Extension as well as in Soil Experiment Fields.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Morgan county was conducted, and Mr. F. W. Wascher, who as leader of the field party, was in direct charge of the mapping.

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MORGAN COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER and L. H. SMITH[1]

Morgan county is located in the west-central part of Illinois. Part of its western boundary is formed by the Illinois river. The location of this county along a water course which at one time carried an immense amount of sediment has an important bearing on the character of the soils, as will appear later.

The climate of Morgan county is typical of central Illinois. It is characterized by a wide range between the extremes of winter and summer and has an abundant, usually well-distributed rainfall. The greatest range in temperature for any one year for the twenty-five years from 1902 to 1927, as recorded at the weather station at Alexander, Illinois, was 127 degrees, in 1914. The highest temperature recorded was 108° in 1918; the lowest, 27° below zero, in 1905. The average date of the last killing frost in spring was April 24; the earliest in the fall, October 16. The average length of the growing season is 175 days.

The average annual rainfall, as recorded at Alexander for this 25-year period, was 36.18 inches. The average rainfall by months for this period was as follows: January, 1.72 inches; February, 1.51; March, 3.02; April, 3.54; May, 4.20; June, 5.02; July, 3.07; August, 4.02; September, 4.56; October, 2.66; November, 2.06; December, 1.80.

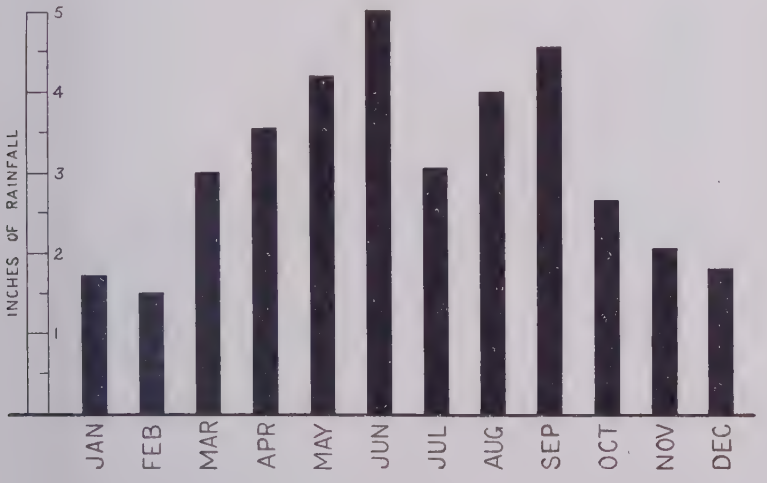


Fig. 1.—Average Monthly Distribution of Rainfall in Morgan County

It will be noted that the more abundant rainfall occurs mainly during the growing season which, of course, is favorable to crop production. The relatively dry July favors the harvesting of grain but the wet June presents an obstacle to the gathering of hay.

[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

AGRICULTURAL PRODUCTION

Morgan county is agricultural in its interest, tho nearly 30 percent of the area of the county is too rough for ordinary farming. According to the United States Census of Agriculture, 1925, there were 2,326 farms in the county, a decrease of 94 since 1920. About 40 percent of the farms were operated by tenants in 1925.

The principal crops are those common to the corn belt, as shown by the following figures for 1924.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn, total acreage	109,084	.....	....
Harvested for grain	97,337	3,815,784 bu.	39.2 bu.
Cut for silage	601	5,105 tons	8.49 tons
Cut for fodder	7,054	.....	....
Hogged off	4,092	.....	....
Wheat	59,065	1,183,199 bu.	20.0 bu.
Oats threshed for grain	25,149	1,023,108 bu.	40.7 bu.
Oats cut and fed unthreshed	4,424	.....	....
Timothy	8,078	.....	....
Timothy and clover mixed	4,828	.....	....
Clover	5,955	.....	....
Alfalfa	1,034	.....	....
Hay of all kinds, both tame and wild	21,130	24,430 tons	1.16 tons

These census figures are for but a single year. For the ten-year period 1916 to 1925 the U. S. Department of Agriculture gives the average yield of corn as 38.8 bushels; oats, 34.3 bushels; winter wheat, 19.4 bushels; and tame hay, 1.37 tons.

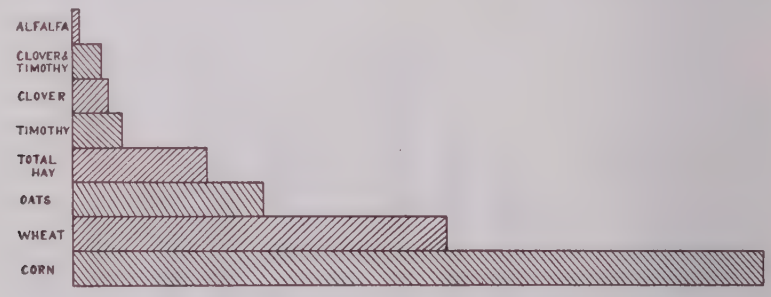
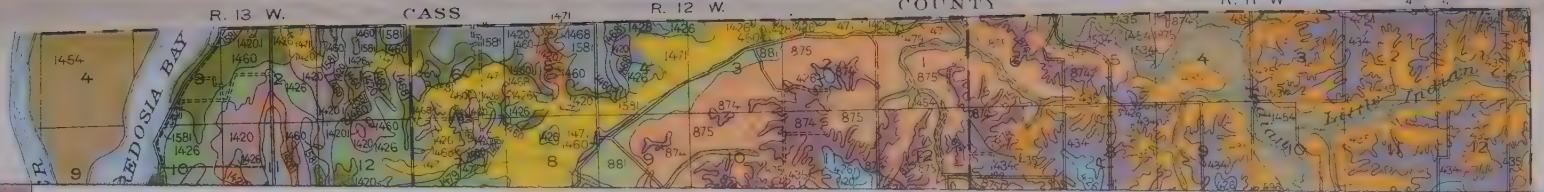


FIG. 2.—RELATIVE ACREAGE OF FIELD CROPS IN MORGAN COUNTY

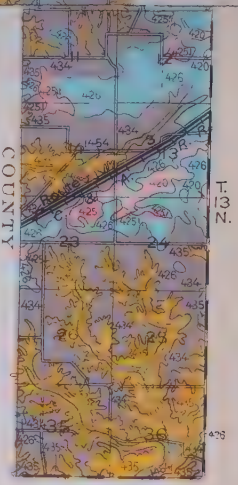
The diagram brings out the preponderance of land devoted to the three grain crops, corn, oats, and wheat. Legume crops might well occupy a larger proportion of the cultivated acreage. (Data from the 1925 Census)

The following figures taken from the 1925 Census show the character of the livestock interests in the county for the year 1924.

Animals and Animal Products	*Number*	*Value*
Horses	11,159	$645,349
Mules	2,417	190,547
Cattle (total)	23,202	904,564
Dairy cows	4,942	.....
Dairy products	.....	326,560
Sheep	6,181	63,091
Swine	70,832	903,436
Chickens and eggs	.....	620,322
Wool	.....	14,798



1420	Black Clay Loam
1420.1	Sandy Black Clay Loam
1415	Drab Clay
1460	Brown Sandy Loam
1471	Brown Fine Sandy Loam
1479	Yellowish Brown Fine Sandy Loam
1454	Mixed Loam
1428	Brown-Gray Silt Loam On Tight Clay



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SOIL SURVEY MAP OF MORGAN COUNTY

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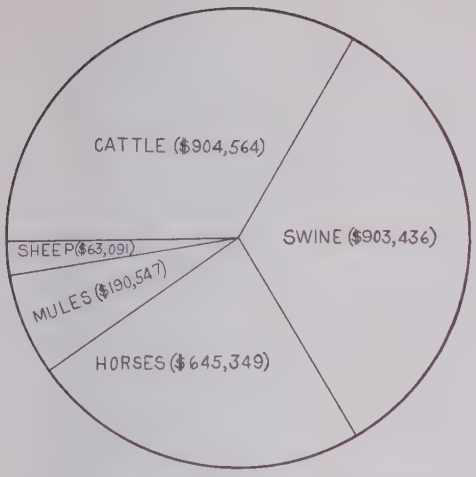


FIG. 3.—RELATIVE VALUE OF THE MORE IMPORTANT CLASSES OF FARM ANIMALS IN MORGAN COUNTY

The value of horses and mules in Morgan county is about equal to that of cattle or of swine. Sheep are of least importance.

SOIL FORMATION

GLACIATION

One of the most important periods in the geological history of the county, from the standpoint of soil formation, was the Glacial period. During and immediately following this remote period, the material that later formed the mineral portion of the soils was being deposited. At that time snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an amount that the mass pushed outward from these centers, chiefly southward, until a region was reached where the ice melted as rapidly as it advanced. In moving across the country from the far north, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even immense masses of rock. Some of these materials were carried for hundreds of miles and rubbed against surface rocks and against each other until largely ground into powder. When the ice sheet, or glacier, reached the limit of its advance, the rock material carried by it accumulated along the front edge in a broad, undulating ridge or moraine. With rapid melting, the terminus of the glacier receded, and the material was deposited somewhat irregularly over the area previously covered. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift. The average depth of this deposit over the state of Illinois is estimated at 115 feet.

Previous to the ice invasion this region was generally rough and hilly in character. Morgan county was covered by the Illinoian glaciation. The general effect of this glacier was to change the surface from hilly to gently undulating by rubbing down the hills and filling the valleys. Only two small moraines were formed in this county. They both occur just west of Jacksonville.

Altho it did not touch the county, a later ice sheet, known as the Iowan, played an important role in the formation of the soils. During the time when the melting ice front of the Iowan glacier lay to the north of the area now comprizing Morgan county, immense volumes of water, heavily laden with fine sediment, flowed from the ice. This water filled the drainage channels and overflowed the adjacent lowlands, forming terraces. Following each flood state, the water would recede and sediment which had been deposited would be picked up by the wind and redeposited on the upland. This wind-blown deposit, known as loess, is the material from which the upland soils of Morgan county are formed.

PHYSIOGRAPHY AND DRAINAGE

As shown by the accompanying drainage map, Morgan county is well provided with drainage channels which have cut back into the upland from Illinois river. The divides are, for most part, flat or slightly undulating and the erosion

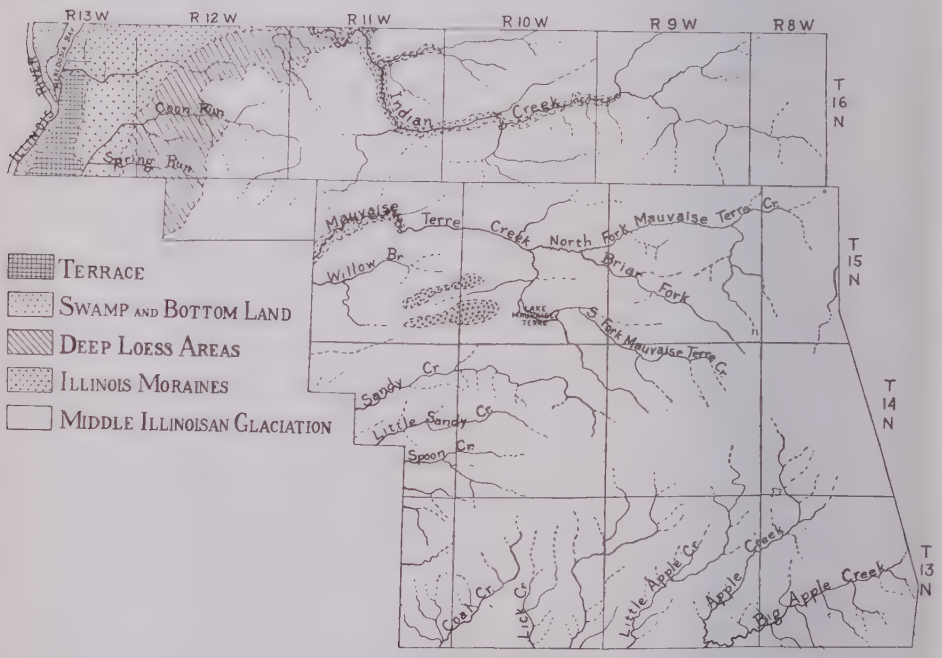
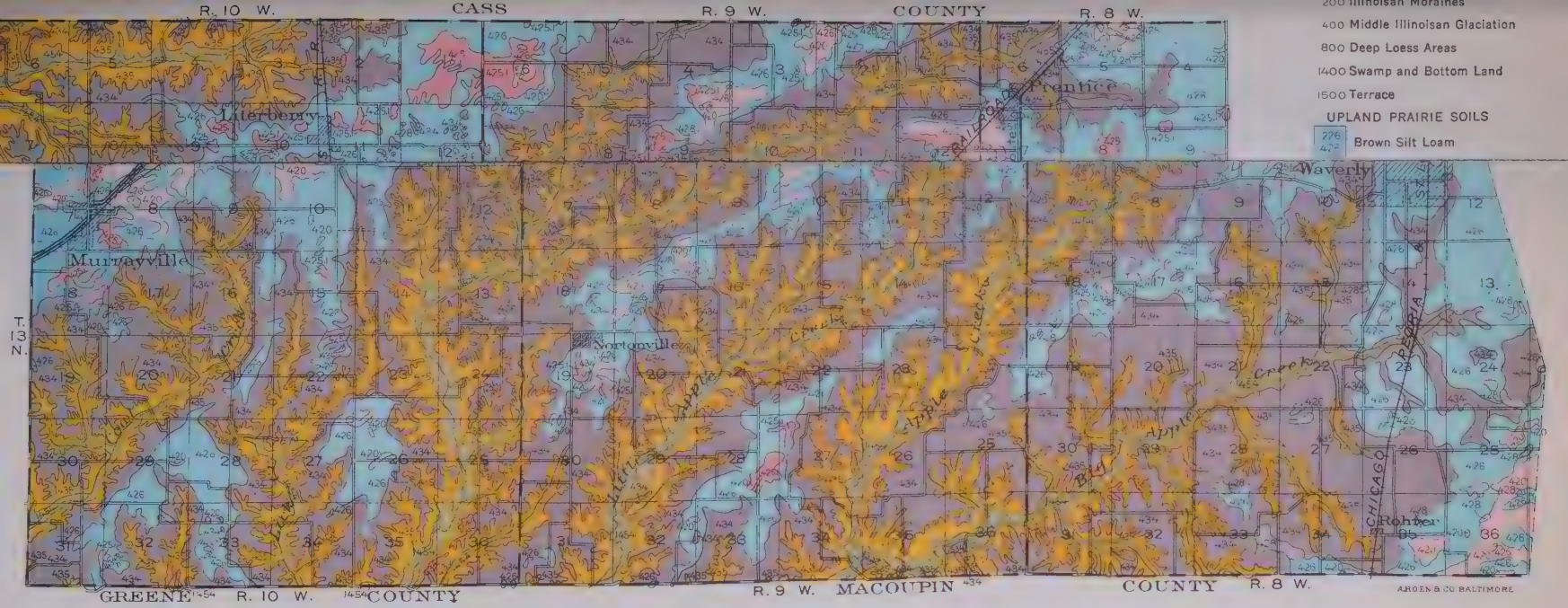


FIG. 4.—DRAINAGE MAP OF MORGAN COUNTY SHOWING STREAM COURSES AND OTHER PHYSIOGRAPHIC FEATURES

slopes on either side of the creeks are steep. The portions of the county which are occupied by the dark-colored soils contain much land which is so nearly level that surface drainage is not good and underdrainage has to be depended on to remove excess water.

SOIL DEVELOPMENT

During the time which has elapsed since the last ice invasion, weathering and other processes have been active, resulting in the formation of the soils of the county as we know them today. When first deposited, the general composition



SOIL SURVEY MAP OF MORGAN COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

of any soil material, particularly loess, is rather uniform. With the passing of time, however, various physical, chemical, and biological agencies of weathering form soil out of the parent material by some or all of the following processes: the leaching of certain elements, the accumulation of others; the chemical reduction of certain compounds, the oxidation of others; the translocation of the finer soil particles, and the arrangement of them into zones or horizons; and the accumulation of organic material from the growth and decay of vegetable material. One of the very pronounced characteristics observed in most soils is that they are composed of more or less distinct strata, called horizons. As explained somewhat more fully in the Appendix, these horizons are named, from the surface down: *A*, which includes the surface and subsurface; *B*, the upper subsoil; and *C*, the lower subsoil. Each of these horizons may be and usually is divided into subdivisions; for example, the surface soil is designated as A_1, and the subsurface as A_2. In case there are subdivisions of the subsurface, each is designated by *A*, so we have in certain soils an A_2, an A_3, and an A_4, all being above the *B* horizon, or upper subsoil.

SOIL GROUPS

The soils of Morgan county have been divided into four groups, as follows:

Upland Prairie Soils, dark colored and usually rich in organic matter, the organic matter having been derived from the decaying roots of the wild prairie grasses which occupied this land for thousands of years.

Upland Timber Soils, including those zones along stream courses over which forests grew for a long period of time. These contain in general less organic matter than the prairie soils.

Terrace Soils, including bench lands and second bottoms formed by deposits from flooded streams overloaded with sediment, perhaps at the time of the melting of the glaciers.

Swamp and Bottom Lands, which include the large flood plain along Illinois river and also the small flood plains along the creeks which provide drainage for Morgan county.

Table 1 gives the list of soil types in Morgan county, the area of each in square miles and in acres, and also the percentage of the total area. The accompanying colored map, shown in two sections, gives the location and boundary of each soil type which has been mapped in the county.

TABLE 1.—SOIL TYPES OF MORGAN COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils (200, 400)			
226, 426	Brown Silt Loam[1]	162.76	104 166	28.52
220, 420	Black Clay Loam	58.53	37 459	10.26
225.1, 425.1	Black Silt Loam On Clay	16.74	10 713	2.93
228, 428	Brown-Gray Silt Loam On Tight Clay	.27	174	.05
		238.30	152 512	41.76
	Upland Timber Soils (400, 800)			
434	Yellow-Gray Silt Loam	170.73	109 267	29.92
435	Yellow Silt Loam	80.20	51 328	14.03
874	Yellow-Gray Fine Sandy Loam	5.68	3 635	1.00
875	Yellow Fine Sandy Loam	14.76	9 446	2.59
881	Dune Sand	2.30	1 472	.40
		273.67	175 148	47.94
	Terrace Soils (1500)			
1534	Yellow-Gray Silt Loam	6.92	4 429	1.21
1581	Dune Sand	.18	115	.03
		7.10	4 544	1.24
	Swamp and Bottom-Land Soils (1400)			
1426	Brown Silt Loam	3.26	2 087	.57
1420	Black Clay Loam	2.06	1 318	.36
1420.1	Sandy Black Clay Loam	.30	192	.05
1415	Drab Clay	.47	301	.09
1460	Brown Sandy Loam	2.62	1 677	.46
1471	Brown Fine Sandy Loam	5.87	3 757	1.03
1479	Yellowish Brown Fine Sandy Loam	3.01	1 927	.53
1454	Mixed Loam	31.17	19 948	5.46
1428	Brown-Gray Silt Loam On Tight Clay	.15	96	.03
1468	Brown-Gray Sandy Loam On Tight Clay	.25	160	.04
1401	Deep Peat	.02	13	.01
		49.18	31 476	8.63
	Water	2.44	1 561	.43
	Total	570.69	365 241	100.00

[1]Including associated types described in the text but not differentiated on the map.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN MORGAN COUNTY SOILS

Three Depths Represented by Soil Samples

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum, over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.
2. A middle stratum extending from 6⅔ to 20 inches, and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches, and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling we have represented separately three zones for plant feeding. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore it is the only stratum whose composition can be greatly changed by adding plant-food materials.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires to consider the information in that form. In comparing the composition of the different strata, it must be kept in mind that it is based on different quantities of soil, as indicated above. The figures for the middle and lower strata must therefore be divided by two and three respectively before being compared with each other or with the figures for the upper stratum.

Wide Range in Organic Matter and Nitrogen

It can readily be seen from Table 2 that there is a wide variation among the different soil types of Morgan county with respect to their content of the different plant-food elements in the upper 6⅔ inches of soil. There appears to be but little relationship among these variations except with respect to organic carbon and nitrogen, the quantities of which run parallel from type to type tho the organic-carbon content is usually 10 to 12 times as great as the nitrogen. This relationship between organic carbon and nitrogen is explained by the well-established fact that all soil organic matter (of which organic carbon is the measure) contains nitrogen and that most of the soil nitrogen—usually 98 per cent or more—is present in a state of organic combination, that is, as a part of the organic matter. This relationship is also maintained in the middle and lower sampling strata.

The upland soils of Morgan county vary in their content of organic matter and nitrogen, the prairie soils being, for the most part, relatively high in these constituents while the timber soils are fairly low. The bottom-land soils likewise vary a great deal in their content of organic matter and of nitrogen. The soils of this group as they occur in Morgan county are in general intermediate between

the upland prairie and timber soils in these constituents. The smallest amounts of both nitrogen and organic carbon, 1,220 and 16,240 pounds per acre respectively, are found in Dune Sand, Terrace. However, a sample of the same type taken in the upland was richer in these constituents than the other upland timber types. This is decidedly better, in fact, than Dune Sand, as it usually occurs.

In sandy soils the rapid oxidation and easy drainage permitted by the open, porous character of the soil result in rapid disappearance of organic materials added. For this reason frequent use of green manuring crops or farm manure where available is particularly important, in order to maintain suitable conditions for crop growth.

Nearly all of the soils of the county diminish rapidly in their content of both organic matter and nitrogen with increasing depth. This diminution is usually noticeable in the second stratum, 6⅔ to 20 inches.

Phosphorus High in Bottom-Land Types

The phosphorus content varies quite as widely as do organic matter and nitrogen. The terrace Dune Sand is strikingly low, with only 580 pounds of this element in 2 million pounds of surface soil. The same type in the upland contains nearly twice as much, but as noted above, the upland Dune Sand in Morgan county is decidedly above the average for this type as it usually occurs. The bottom-land types run generally higher in this element than do most of the upland types. However, two bottom-land types contain less than 1,000 pounds, namely, Brown Sandy Loam and Brown-Gray Silt Loam On Tight Clay. On the whole, soils which are very high in organic matter are usually somewhat high in total phosphorus.

Phosphorus, in contrast with some other elements, is not appreciably removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in plant residues at the expense of underlying strata. Investigations at the Illinois Station have shown that in Brown Silt Loam, for example, about 33 percent of the total phosphorus of the surface soil is organic, and in Black Clay Loam about 37 percent. It is the second stratum (6⅔ to 20 inches) which furnishes most of the phosphorus thus moved upward. Consequently in the majority of the soil types in Morgan county the surface soil contains a larger proportion of phosphorus than the middle stratum and, in some cases, more than the lower stratum.

Sulfur Generally Well Supplied

While other elements are not so closely associated with each other as are organic matter and nitrogen, there is some degree of correlation between sulfur, another element used by growing plants, and organic carbon. This is because a considerable tho varying proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of organic matter.

Morgan county soils are only fairly well supplied with sulfur. It ranges, in the surface soil, from a minimum of 80 pounds an acre in Dune Sand, Terrace, up to 1,110 pounds in Black Clay Loam. The average in Morgan county soils is a little more than half that of phosphorus.

The sulfur content decreases with depth in nearly all cases, as may be seen from a comparison of the figures in Tables 2, 3, and 4. This is to be expected since, as stated above, a portion of the sulfur exists in combination with the organic matter of the soil, and not only is the organic matter more abundant in the upper stratum, but also the organic forms of sulfur are held more tenaciously against the leaching action of water than are the inorganic forms.

If growing crops were dependent entirely upon the sulfur contained in the soil for their supply for growth, it would appear questionable from these analyses whether there might be some need for added sulfur fertilizers.

The sulfur available to crops, however, depends not only on the soil supply, but also on the amount brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption, the amount of sulfur thus added to the soil is relatively large. At Urbana during the eight-year period from 1917 to 1924 there was added to the soil by the rainfall an average of 3.5 pounds of sulfur an acre a month. Similar observations have been made in other localities for shorter periods. The precipitation at the various points in the state in a single month has been found to vary from a minimum of three-fourths of a pound to more than 10 pounds an acre.

These figures afford some idea of the amounts of sulfur added by rain and also of the wide variations in amount under different conditions. Considering the amounts which are brought down in rainfall in addition to the soil supply, the facts would indicate that apparently there is little need for sulfur fertilizers in Morgan county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started on a number of experiment fields in different parts of the state.

Potassium Content Varies Thruout County

The potassium content of the various soil types also exhibits considerable variation. Dune Sand is noticeably low, especially in the terrace, where it amounts to only 11,580 pounds in the surface soil. Sand soils carry a large proportion of their potassium in the sand grains. The relatively smaller surface exposed in the case of these coarser soil particles greatly lowers the rate at which potassium is dissolved and hence its availability. The deficiency of available potassium in the sandy soils may be partly, if not wholly, offset by the greater facility with which crop roots can penetrate soils of that character as compared with the heavier types. In the other types the potassium content ranges from 17,560 pounds to 35,530 pounds per acre in the surface soil. These amounts are somewhat below those frequently found in the same types as they occur in other counties. However, the total amount is so greatly in excess of crop requirements that the matter of soil management for its liberation, such as good rotations and green manuring, is probably of greater importance than potassium fertilization. The potassium concentration shows practically no variation at different depths.

Calcium and Magnesium Vary Widely Within the Type

The variations in the amounts of calcium and magnesium present in the soils of Morgan county are very wide. Only two of the types, Dune Sand, Terrace, and Brown Sandy Loam, Bottom, are particularly low in either of these elements. In very acid soils it sometimes happens that the calcium present is in such highly insoluble forms that it does not become available rapidly enough for crop growth. The benefit realized from liming such soils may therefore be due, not wholly to the correction of acidity, but probably in part to the fact that the limestone supplies calcium as a plant-food element in a form which rapidly becomes available.

Variations in the amounts of calcium and magnesium in the different depths of those soils which do not contain native calcium carbonate furnish a clue as to the translocations of these elements during the long period in which the different types were developing. In the surface stratum calcium exceeds magnesium in most cases. This would indicate a larger percentage of calcium than of magnesium in the soil-forming materials. The idea is also in harmony with geological evidence. In the second stratum we find the calcium concentration about the same as in the surface, or slightly less, while an increase in magnesium occurs in the second stratum and becomes very pronounced in the lower.

This situation may be explained by the fact that as these two elements are dissolved from the surface soil, they are carried downward in solution. In the downward movement the nature of magnesium causes it to be more rapidly reabsorbed by the soil mass than calcium, tending to force the calcium into the solution to be carried farther down. Consequently, while magnesium begins to accumulate in the middle stratum as well as the lower, the liberated calcium generally begins to accumulate in the third or at still greater depths or may be washed away entirely. These movements of calcium and magnesium, as indicated by the analyses of the different strata, constitute one factor in estimating the relative maturity of the various soil types. The increasing proportion of magnesium to calcium in the lower levels, as compared with the surface soil, tends to be more pronounced in more fully developed or mature profiles. Thus we see a correlation of this chemical characteristic of the soil with the processes of its development.

Some of the calcium figures, as given in the tables, appear to be very erratic. The very large amounts of calcium in some of the types are the result of the presence of finely divided native calcium carbonate (limestone) in some or all of the samples of such types. Sometimes calcium carbonate is present in the surface stratum, and when this is the case it will be found also in the underlying layers. An example is the Dune Sand, Upland, which is in sharp contrast to the same type as sampled in the terrace, where it is acid to the full depth sampled. In the calcareous Dune Sand we have 134,100 pounds of calcium in an acre of surface soil, 284,840 pounds in the middle stratum and 528,180 pounds in the lower. In the acid areas of Dune Sand the amounts of calcium in the three layers are only 5,180 pounds, 9,120 pounds and 15,720 pounds, respectively. Calcium carbonate is readily soluble in the soil water and as it is removed by leaching it disappears from the surface soil first. Thus soils are frequently en-

countered which contain calcium carbonate in the deeper levels even tho the surface soil is acid. This is the case in Yellow Silt Loam. Here the surface soil is acid, yet it contains 13,800 pounds of total calcium. The second stratum still contains some of its calcium carbonate and therefore has not yet become acid. The calcium content is 89,880 pounds. The lower stratum is still heavily charged with calcium carbonate and contains 249,480 pounds of calcium in 6 million pounds of soil, which after converting to the 2 million pound basis for comparison with the surface stratum is found to be more than six times as concentrated.

Some increase in total magnesium ordinarily accompanies the high calcium of the carbonate-containing soils. The increases are not great, however, because of the inability of magnesium to persist in the soil in the form of carbonate. The carbonate of carbonate-containing soils is chiefly that of calcium.

Local Tests for Soil Acidity Often Required

It is impracticable to attempt to obtain an average quantitative measure of the calcium carbonate or acidity present in a given soil type because, while some samples may contain large amounts of calcium carbonate, others may contain none, or may actually have a lime-requirement due to soil acidity. We thus have what might be considered positive and negative values ranging, perhaps widely, on the opposite sides of the zero or neutral point, the numerical average of which could have no significance whatever, since such an average would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types.

The qualitative field tests made in the process of the soil survey are much more numerous than the chemical analyses made in the laboratory, and do give a general idea of the predominating condition in the various types as to acidity or alkalinity. These tests, therefore, furnish the basis for some general recommendations, which are given in the descriptions of individual types on pages 15 to 24. To have a sound basis for the application of limestone the owner or operator of a farm must in many cases determine individually the lime requirements of his different fields. The section in the Appendix dealing with the application of limestone (page 33) is pertinent and should be read in this connection.

Supplies of Different Elements Not Proportional to Crop Removal

In the foregoing discussion we have considered mainly the amounts of the plant-food elements in the surface 6⅔ inches of soil, and rather briefly the relative amounts in the two lower strata. We have noted that some of the elements of plant-food exhibit no consistent change in amount with increasing depth. Other elements show more or less marked variation at the different levels, the trend of these variations serving in some cases as clues to the relative maturity of different types and the processes involved in their development.

By adding together the figures for all three strata, as given in Tables 2, 3, and 4, we have an approximate invoice of the total plant-food elements within the feeding range of most of our field crops, since the major portion of their

TABLE 2.—MORGAN COUNTY SOILS: PLANT-FOOD ELEMENTS IN UPPER SAMPLING STRATUM, ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 400)							
226, 426	Brown Silt Loam	59 310	4 770	970	810	19 740	7 190	10 120
220, 420	Black Clay Loam	71 400	6 190	1 480	1 110	18 070	11 760	17 930
225.1, 425.1	Black Silt Loam On Clay	69 020	5 070	990	760	18 000	8 300	20 910
228, 428	Brown-Gray Silt Loam On Tight Clay[1]	30 490	2 700	680	[2]	35 530	5 320	8 630
	Upland Timber Soils (400, 800)							
434	Yellow-Gray Silt Loam	31 690	3 100	750	570	21 200	5 470	7 050
435	Yellow Silt Loam	21 740	1 880	1 140	360	23 300	5 880	13 800
874	Yellow-Gray Fine Sandy Loam	21 640	2 220	540	120	20 220	4 040	10 220
875	Yellow Fine Sandy Loam	18 160	1 940	1 240	440	23 380	7 920	16 600
881	Dune Sand	36 660	3 680	920	640	16 500	59 980	134 100
	Terrace Soils (1500)							
1534	Yellow-Gray Silt Loam[3]	.....	.....	.....	.....	.....	.....	.....
1581	Dune Sand	16 240	1 220	580	80	11 580	1 760	5 180
	Swamp and Bottom-Land Soils (1400)							
1426	Brown Silt Loam	47 540	3 360	1 660	660	21 280	8 300	17 800
1420	Black Clay Loam	51 380	4 500	1 240	800	18 220	7 880	22 120
1420.1	Sandy Black Clay Loam	50 280	4 340	1 300	680	18 820	5 780	14 420
1415	Drab Clay	47 920	4 260	1 660	980	21 960	8 320	11 960
1460	Brown Sandy Loam	20 360	1 640	800	340	17 560	2 820	5 600
1471	Brown Fine Sandy Loam	43 880	3 400	1 600	540	21 300	5 680	10 560
1479	Yellowish Brown Fine Sandy Loam	28 700	2 320	1 100	720	21 700	4 320	6 060
1454	Mixed Loam[4]	.....	.....	.....	.....	.....	.....	.....
1428	Brown-Gray Silt Loam On Tight Clay	37 980	3 360	880	360	22 740	4 820	10 020
1468	Brown-Gray Sandy Loam On Tight Clay	54 920	5 720	1 420	700	21 040	9 100	18 700
1401	Deep Peat[5]	.....	.....	.....	.....	.....	.....	.....

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]Samples from an adjoining county were used in these averages. [2]Sulfur analysis not available. [3]See data for soil type No. 434. [4]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type. [5]This type was not sampled.

feeding range is included in the upper 40 inches. One of the most striking facts brought out of this consideration of the data is the great variation within a given soil type in the relative abundance of the various elements present as compared with the amounts removed by crops. In one of the important types in the county, Brown Silt Loam, Upland, we find that the total quantity of nitrogen in all three strata is 18,070 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus is a little over one-fourth as much, or 4,760 pounds, but this amount

TABLE 3.—MORGAN COUNTY SOILS: PLANT-FOOD ELEMENTS IN MIDDLE SAMPLING STRATUM, ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 400)							
226 426	Brown Silt Loam	90 910	7 720	1 670	1 480	38 910	18 250	26 590
220 420	Black Clay Loam	99 430	8 560	2 590	1 840	36 110	22 670	36 130
225.1 425.1	Black Silt Loam On Clay	91 020	6 860	1 740	1 380	35 440	18 900	30 200
228 428	Brown-Gray Silt Loam On Tight Clay[1]	31 680	2 760	1 120	(2)	70 660	15 180	16 880
	Upland Timber Soils (400, 800)							
434	Yellow-Gray Silt Loam[3]	39 510	4 200	1 390	850	42 040	15 040	12 920
435	Yellow Silt Loam	18 160	1 680	2 360	440	44 080	50 720	89 880
874	Yellow-Gray Fine Sandy Loam	28 080	3 000	800	160	41 360	15 800	17 320
875	Yellow Fine Sandy Loam	18 520	2 200	2 400	160	46 960	23 680	48 040
881	Dune Sand	53 120	5 120	1 480	1 280	33 160	52 920	284 840
	Terrace Soils (1500)							
1534	Yellow-Gray Silt Loam[3]	.....	.....	.....	.....	.....	.....	.....
1581	Dune Sand	19 200	1 040	1 160	280	23 000	4 520	9 120
	Swamp and Bottom-Land Soils (1400)							
1426	Brown Silt Loam	69 920	4 360	2 640	600	42 360	13 920	24 360
1420	Black Clay Loam	72 040	5 840	1 960	1 200	37 280	18 440	32 200
1420.1	Sandy Black Clay Loam	69 560	6 120	2 240	1 000	38 240	19 320	31 760
1415	Drab Clay	84 560	7 840	3 400	1 560	43 640	18 280	31 640
1460	Brown Sandy Loam	38 880	3 600	1 320	400	37 440	6 640	6 720
1471	Brown Fine Sandy Loam	82 280	6 520	3 240	1 000	43 680	9 600	17 040
1479	Yellowish Brown Fine Sandy Loam	57 320	4 720	2 280	1 000	43 680	5 400	13 920
1454	Mixed Loam[4]	.....	.....	.....	.....	.....	.....	.....
1428	Brown-Gray Silt Loam On Tight Clay	42 080	3 160	920	200	44 120	10 560	16 800
1468	Brown-Gray Sandy Loam On Tight Clay	52 760	4 880	2 600	400	40 560	15 160	39 840
1401	Deep Peat[5]	.....	.....	.....	.....	.....	.....	.....

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Samples from an adjoining county were used in these averages. [2]Sulfur analyses not available. [3]See data for soil type No. 434. [4]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type. [5]This type was not sampled.

is equivalent to the phosphorus in about 50 percent more corn, namely, 28,000 bushels. In the surface stratum, however, which is the zone of most intensive crop feeding, we find the relative amounts of nitrogen and phosphorus more nearly in accord with the rate of removal of these elements by crops. Here the nitrogen is equivalent to 4,770 bushels of corn, and the phosphorus to 5,700 bushels.

Other types show marked contrast to the Brown Silt Loam, just discussed, with respect to total supply in relation to rate of removal by crops. However, in most soils except those which are peaty, phosphorus is more abundant than nitrogen when considered in terms of crop equivalents rather than the actual number of pounds per acre of the respective elements.

TABLE 4.—MORGAN COUNTY SOILS: PLANT-FOOD ELEMENTS IN LOWER SAMPLING STRATA, ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (200, 400)							
226 426	Brown Silt Loam	58 860	5 580	2 120	1 280	61 120	31 720	33 100
220 420	Black Clay Loam	54 750	4 580	3 060	1 220	55 060	39 860	69 180
225.1 425.1	Black Silt Loam On Clay	47 220	4 140	2 640	1 440	54 000	35 340	46 230
228 428	Brown-Gray Silt Loam On Tight Clay[1]	37 110	3 720	2 490	([2])	97 650	36 810	33 000
	Upland Timber Soils (400, 800)							
434	Yellow-Gray Silt Loam	37 980	3 960	2 600	1 300	63 320	30 020	17 300
435	Yellow Silt Loam	21 000	1 320	3 660	240	61 800	127 380	249 480
874	Yellow-Gray Fine Sandy Loam	35 280	3 960	1 920	300	61 020	48 000	57 900
875	Yellow Fine Sandy Loam	26 640	1 500	3 120	240	71 940	29 100	60 660
881	Dune Sand	28 200	4 020	2 340	1 260	46 200	31 680	528 180
	Terrace Soils (1500)							
1534	Yellow-Gray Silt Loam[3]	.....	.....	.....	.....	.....	.....	.....
1581	Dune Sand	18 600	2 520	1 560	180	34 500	4 800	15 720
	Swamp and Bottom-Land Soils (1400)							
1426	Brown Silt Loam	59 220	3 060	3 840	720	62 160	22 440	34 320
1420	Black Clay Loam	57 300	4 500	2 340	1 320	60 720	32 520	42 300
1420.1	Sandy Black Clay Loam	59 220	5 460	2 520	720	56 580	30 540	46 920
1415	Drab Clay	95 340	9 420	4 440	1 620	65 640	26 160	45 360
1460	Brown Sandy Loam	43 080	3 720	1 800	1 080	56 520	14 460	11 520
1471	Brown Fine Sandy Loam	71 460	5 580	4 440	900	68 580	17 700	39 240
1479	Yellowish Brown Fine Sandy Loam	78 960	5 580	3 240	1 680	66 060	29 760	56 700
1454	Mixed Loam[4]	.....	.....	.....	.....	.....	.....	.....
1428	Brown-Gray Silt Loam On Tight Clay	42 480	3 000	3 600	240	64 500	19 380	24 960
1468	Brown-Gray Sandy Loam On Tight Clay	46 140	3 600	7 260	1 080	62 880	15 840	24 060
1401	Deep Peat[5]	.....	.....	.....	.....	.....	.....	.....

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Samples from an adjoining county were used in these averages. [2]Sulfur analysis not available. [3]See data for soil type No. 434. [4]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type. [5]This type was not sampled.

The 120,000 pounds of potassium present in Brown Silt Loam is equivalent to the amount of this element which is contained in over a half million bushels of corn.

Practical Value and Limitations of Soil Analyses

The foregoing discussion should not be taken to mean that it is possible to predict how long any certain soil could be cropped under a given system before it would become exhausted. Nor do the figures alone indicate the immediate procedure to be followed in the improvement of a soil. It must be kept in mind that the *amount* of plant-food shown to be present is not the sole measure of the ability of a soil to produce crops. The *rate* at which these elements are liberated from insoluble forms and converted to forms that can be used by growing

plants is a matter of at least equal importance (as explained on page 31), and is not necessarily proportional to the total stocks present. One must know, therefore, how to cope with the peculiarities of a given soil type, if he is to secure the full benefit from its stores of the plant-food elements. In addition there are always economic factors that must be taken into consideration, since it is necessary for one to decide at how high a level of productive capacity he can best afford to maintain his soil.

The chemical soil analysis made in connection with the soil survey is seen to be of value chiefly in two ways. In the first place it reveals at once outstanding deficiencies or other chemical characteristics which alone would affect its productivity to a marked extent, or point the way to corrective measures. It should be borne in mind, however, that fairly wide departures from the usual are necessary before the chemical analysis alone can be followed as a guide in practice without supplementary information from other sources. As examples of the direct use of the results of chemical investigations may be mentioned the following cases: the marked shortage of potassium in peat soils associated with the need for potassium fertilizers, and the determination of the lime need of soils by chemical tests. It is quite probable that the results of chemical soil analyses are frequently misused by attempting to interpret small differences in the amount of a certain plant-food element as indicative of similar differences in the fertilizer need. For example, differences of 100 or 200 pounds of phosphorus per acre in soils containing 1,000 pounds or thereabout should not be considered as of any agricultural significance. Again, the addition of 100 pounds of active nitrogen made by plowing down a clover crop may be of more importance to the succeeding crop than a difference in soil composition of 1,000 pounds of nitrogen.

The second function of soil analysis is to aid in the scientific study of soils from many angles, the ultimate aim of which is, of course, the more economical utilization of the soil for efficient crop production. Not only do chemical studies aid in determining the processes involved in soil development under natural conditions, but also in determining the effects of different soil management and fertilizing practices upon the soil and upon the utilization by crops of the plant-food elements involved.

DESCRIPTION OF SOIL TYPES

UPLAND PRAIRIE SOILS

The upland prairie soils of Morgan county occupy 238.30 square miles, or somewhat less than half the upland area of the county. These soils are uniformly dark in color. There is, however, considerable difference in the color, not only of the various types, but within types, particularly in the case of Brown Silt Loam. The dark color of the prairie soils is due to an accumulation of organic matter from the fibrous roots of the prairie grasses that grew on this land for centuries. A covering of fine soil and a mat of vegetative material by partially excluding the oxygen protected these roots from rapid and complete

decay. From time to time the mat of old grass stems and leaves was partially destroyed by prairie fires and decay, but it was constantly being renewed, and while it added but little organic matter to the soil directly, it served to retard the decay.

The upland prairie soils in this county include some areas of recent timber growth, where certain kinds of trees have spread over the prairie, but this forestation has not been of sufficient duration to produce the characteristic timber soils. These areas of greater or less width are found along the border of most timber tracts and also on the morainal ridges near Jacksonville.

Brown Silt Loam (226, 426)

Brown Silt Loam, as mapped in Morgan county, occupies 162.76 square miles. It varies in character depending on topography, and would now be separated into at least three types. Each of these differs from the other in character of soil profile, in agricultural value, and in treatment and fertilizer requirements. In the following discussion these types, even tho not shown on the map, are described in such a way that it should not be difficult to recognize each one in the field.

1. Light Brown Silt Loam. This prairie type occurs on areas where the surface drainage is good or even excessive. It has a light brown or even yellowish brown surface, or A_1 horizon. Below the surface horizon, which is usually about 7 inches thick, the material is distinctly yellowish brown and is very friable and permeable. The subsoil, or B horizon, is not easily distinguished because of the absence of much clay accumulation and its consequent friability. It differs, however, from the subsurface, or A_2 horizon, immediately above it in being somewhat less friable, finer in texture, and slightly reddish yellow in color. Other differences, which need not be described here, also help in distinguishing it. Immediately below this subsoil layer, usually at a depth of about 36 inches, the material is very friable and permeable again and is more of a pale yellow in color. The outstanding feature which characterizes this type, as contrasted to the other two about to be described, is its permeability thruout the entire section. This characteristic, together with its topographic position, gives it perfect surface drainage and underdrainage, thus allowing deep root penetration.

Management.—Care must be exercised in farming this type to prevent erosion. Much of the surface material is easily carried off in the form of little-noticed sheet erosion. This soil is not high in organic matter, as its color shows, and therefore is lower in nitrogen than the darker soils. It is medium acid and requires about 3 tons, and in some cases 4 tons, of limestone an acre for alfalfa or sweet clover. The best information available on the treatment of this type comes from the Mt. Morris and Dixon experiment fields which are located in part on Light Brown Silt Loam. The results from these fields show a very marked response to manure. Where limestone was applied in addition to manure, a further increase was secured which was sufficiently large to pay a good profit on the cost of the limestone. Another treatment which has given very good increases is residues and limestone used in combination. Potash has not increased

the yields sufficiently to justify its use. Rock phosphate has not been effective in either the manure or residues systems and its use on this soil cannot be advised on the basis of present information. The reader is asked to turn to pages 44 and 46 for the summarized yields on the Mt. Morris and Dixon fields.

2. **Brown Silt Loam.** This type occupies intermediate topographic positions. It occurs neither on the flat areas nor on the very well-drained slopes. The surface, or A_1 horizon, is darker colored and usually thicker than that of the preceding type, Light Brown Silt Loam; the yellow color of the subsurface, or A_2 horizon, is not so pronounced; and the subsoil, or B horizon, is heavier, less friable, and of a different color. Other differences which are chiefly of technical interest may be omitted here.

Management.—Brown Silt Loam is somewhat less acid than Light Brown Silt Loam but requires limestone to grow alfalfa, sweet clover, or the best red clover. It was originally well supplied with organic matter and has been subject to but little loss of soil material thru erosion. The Kewanee experiment field is located, for the most part, on this soil type. A description of the work on this field, including the experimental data, will be found on page 48. Unfortunately the Kewanee field has several draws crossing the plots, which are a much heavier soil, so that the results from the field cannot be applied to Brown Silt Loam with as much confidence as would otherwise be the case. It is almost certainly true, however, that the presence of the heavier type on the Kewanee field has the effect of diminishing the increases due to treatment. This field shows very good results for manure on corn and oats, but less effect on wheat. Limestone has given profitable increases, particularly in the residues system. Rock phosphate has produced a profitable return in the residues system but has failed to pay for its cost in the manure system. A comparison of rock and superphosphate (acid phosphate) on the Kewanee field, which has been in progress too short a time to allow final conclusions, suggests that better results might be secured on this soil type with superphosphate than with rock phosphate. The need for some form of phosphate is also indicated by the results from the Bloomington field (see page 50), which is located in part on this soil type.

The only concrete suggestion for the fertilization of this soil type which can be made at the present time is that if manure is not available one of the phosphates be applied for wheat after taking care of the nitrogen needs by growing legumes.

3. **Brown Silt Loam On Clay.** This type occupies the nearly level or only gently sloping areas of the upland prairie. Its occurrence should not be confused with the occurrence of the other dark-colored types described below. It is characterized by a dark brown surface soil, or A_1 horizon, which is usually 9 or 10 inches thick. The subsurface, or A_2 horizon, is often darker and heavier than the surface and breaks into well-defined granules. The subsoil, or B horizon, occurs at a depth of about 18 inches and is heavy and fairly plastic. The angular granules in the upper portion of this horizon are coated with black and in the lower portion with drab. At a depth of about 38 inches the color becomes gray or drab and there are numerous reddish yellow spots present.

Management.—This type is either not acid or only slightly so. The subsoil, while more compact and plastic than that of either of the preceding types discussed, drains well with tile. The Aledo experiment field is located on Brown Silt Loam On Clay, and the results from this field may be used as a guide in the treatment of this soil type in Morgan county. Manure has given very good returns on this field. Limestone is showing more benefit than it did at first and without it sweet clover has failed to grow. It is advisable, however, on this soil type to make the test for soil acidity before applying limestone. Especially is this important in preparing for alfalfa and sweet clover, for there are portions of the type on which these crops will not grow without liming. Rock phosphate has not caused increases in yield on the manure plots. On the residues plots some increases have followed its use, but with present information as a basis the use of this material on this soil cannot be advised at this time. Phosphate comparisons have been in progress on the Aledo field since 1916, and the reader is asked to turn to page 54 and make a study of the results there discussed, as an aid in solving his phosphate problem on Brown Silt Loam On Clay.

Black Clay Loam (220, 420)

Black Clay Loam is well distributed thruout the dark-soil portions of Morgan county, occupying, all told, nearly 60 square miles. This type is now recognized as made up of two or more types. The several types, however, cannot be easily recognized in the field in spite of the fact that soil differences are associated with topographic differences. The difference in topography between the flat and slightly undulating areas is often so small as to be unnoticed unless attention is called to it. No distinction is made on the map, and a generalized description only can be written for the reason noted above. The surface, or A_1 horizon, is black and heavy and is about 9 inches thick. Below this, to a depth of 16 to 18 inches, the material is drabbish black and is usually heavier than the surface. The subsoil, or *B* horizon, varies in color, plasticity, and other features, depending on which type, as now recognized, is present. In any event it is of such nature that it underdrains satisfactorily.

Management.—The type as mapped varies in lime requirement. The flat, nearly level areas will grow good sweet clover without lime, while the slightly undulating portions require 1 to 2 tons an acre. Particular attention is called to the slight difference in topography, not readily discernible, which is associated with this difference in lime requirement.

Black Clay Loam is a productive soil and needs no treatment other than limestone, as above noted, and fresh organic matter to help keep it in good physical condition. The reader is asked to turn to page 59, where the results and discussion of the Hartsburg experiment field, which is located on this soil type, will be found.

Black Silt Loam On Clay (225.1, 425.1)

Black Silt Loam On Clay occurs thruout the dark-soil portions of Morgan county in association with Black Clay Loam. It differs from the latter type chiefly in having a silty surface, or A_1 horizon, as a result of its topographic

position, which is such as to subject it to the deposition of sediment. It is a highly productive soil when well drained and is somewhat easier to work than Black Clay Loam. It occupies a total of nearly 17 square miles in Morgan county and is of considerable agricultural importance even tho of relatively small total area.

Management.—The management recommended for this type is the same as that described for Black Clay Loam, with the exception that rarely, if ever, is limestone needed for good sweet-clover growth. Alkali occurs infrequently on this soil. In places where it is sufficiently concentrated to be harmful, the bad effects may be overcome by the use of potash and the condition slowly improved by good underdrainage.

Brown-Gray Silt Loam On Tight Clay (228, 428)

Brown-Gray Silt Loam On Tight Clay, Upland, is of little importance in Morgan county because of its small total area. Slightly over 170 acres is all that is found and practically all of it occurs in a few small areas in the southeastern corner of the county. It is characterized by a grayish-brown surface soil, or A_1 horizon, a gray subsurface, or A_2 horizon, and a very plastic impervious subsoil, or B horizon.

Management.—This type requires from 2 to 4 tons of limestone an acre for sweet clover, except on spots, of varying size, where lime is present in abundance. These spots are locally known as "slick spots" or "scald spots," and no lime should be applied to them without the advice of the farm adviser or the Experiment Station. Drainage must be taken care of on this soil thru furrows and open ditches. Further suggestions for the management of this soil may be had from the farm adviser or by correspondence with the Agricultural Experiment Station.

UPLAND TIMBER SOILS

The upland timber soils in Morgan county exceed in area the upland prairie soils. They occur adjacent to the streams, presumably because, with the development of natural drainage, conditions became favorable for tree growth. That is to say, forests invaded the prairie as the streams cut their way back by headwater erosion and furnished drainage for the intermittent swamps, which were common. These soils are yellowish gray in color, indicating a deficiency in organic matter. This deficiency results from conditions produced as the forests invaded the prairies. The shade of the trees prevented the growth of grasses, the roots of which are mainly responsible for the large amount of organic matter in the prairie soils, and the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed or were destroyed by forest fires.

Yellow-Gray Silt Loam (434)

Yellow-Gray Silt Loam is the most extensive type in Morgan county, aggregating a total of about 171 square miles. It is now recognized that the type as mapped in Morgan county includes three types each of which is definitely cor-

related with topography. No. 1 occurs on flat, practically level areas; No. 2 on areas of an intermediate or gentle slope; No. 3 on slopes that are very pronounced but which are not sufficiently steep to be classed with eroded land.

Type No. 1, which occurs on the nearly level areas has a gray or slightly brownish gray surface soil, or A_1 horizon, an ashy gray or almost white subsurface, or A_2 horizon, and a subsoil, or B horizon, which is so plastic and compact as to be only slowly permeable to water. The subsoil is perhaps sufficiently impervious to be called "tight clay," but this soil should not be confused with the light-colored tight-clay soils which occur farther south in the state.

Management.—The level areas of Yellow-Gray Silt Loam are strongly acid and low in nitrogen and organic matter. The greatest difficulty encountered in the improvement of this soil is its poor surface drainage and underdrainage. Tile do not draw well because of the nature of the subsoil, and excess water must therefore be taken care of by means of open ditches and furrows. This is sometimes difficult to accomplish because of the nearly level topography. Sweet clover does well on this soil following the application of 3 or 4 tons of limestone an acre. Satisfactory corn crops can be grown following sweet clover, except during seasons which are climatically unfavorable, and small grain may be grown following the corn. This soil is probably best adapted to hay, but in any event limestone must be applied for satisfactory results.

Type No. 2, constituting the undulating portions of Yellow-Gray Silt Loam, is made up of a soil very different from that on the level areas described above. The surface, or A_1 horizon, has a distinctly yellowish cast, the subsurface, or A_2 horizon, is a drabbish gray, never ashy, and the subsoil, or B horizon, is not impervious tho it is compact. Surface drainage and underdrainage are both good on this soil.

Management.—This soil is somewhat less acid than No. 1, but it is nearly as deficient in nitrogen and organic matter. Detailed tests should be made to determine the exact amount of limestone necessary, and following its application sweet clover should be grown in preparation for corn and the small grains. No information is available from experiment fields as to the treatment of this soil. There appears to be no question but that the application of limestone and the growing of sweet clover should be the first step in its improvement. Following this, it is suggested that superphosphate (acid phosphate) be applied for wheat. Rock phosphate may be used instead of superphosphate, tho which would be the more economical cannot be stated without accurate experimental evidence.

Type No. 3, on the rolling portions of Yellow-Gray Silt Loam, is much less extensive than the undulating type described above. This soil has good underdrainage, and the slopes are steep enough to allow such rapid runoff as to be harmful unless precautions are taken to control it. The surface soil, or A_1 horizon, is shallow, rarely exceeding 6 or 7 inches in depth. It contains less gray and more yellow and red material than the more level-lying types. The subsurface, or A_2 horizon, is distinctly gray but frequently is only a very thin layer and is never white and ashy. The subsoil, or B horizon, is non-plastic but may be compact. It is dull brick red in color on the best drained areas.

Management.—This soil is deficient in organic matter, is acid, and requires careful handling to reduce erosion to the minimum. It is a good fruit soil and is well adapted to alfalfa following the application of limestone. The amount of limestone needed varies, but probably is never less than 2 tons an acre for sweet-clover or alfalfa. Detailed tests should be made of each field before liming. It is questionable whether any treatment other than the application of limestone and the growing of sweet-clover should be attempted on this soil.

Yellow Silt Loam (435)

Yellow Silt Loam is extensively developed in Morgan county, occupying a total of 80 square miles. Much of it is unsuited to general farming because of its steep topography. Erosion is active, and surface, subsurface, and subsoil horizons therefore have not usually been developed. However, where there has been sufficient protection to greatly retard the rate of erosion, a shallow surface soil has formed.

Management.—Yellow Silt Loam should, for the most part, be used for permanent pasture, orchard, or timber. There are areas having a slope sufficiently gentle to be farmed successfully if care is taken to reduce erosion to the minimum. A very good use to make of the less-steep slopes is to seed alfalfa after applying limestone. If the alfalfa is preceded by sweet clover, little difficulty should be encountered in getting a stand. See Vienna Field experiments, page 60.

Yellow-Gray Fine Sandy Loam (874)

Yellow-Gray Fine Sandy Loam is very similar to Yellow-Gray Silt Loam. It differs from the silt loam in that it is somewhat coarser in texture, particularly immediately adjacent to the bluffs, it is somewhat less acid, and a smaller proportion of it is level lying. Both these types are formed from loess, but as the loess was blown from the bottom land to the west the coarser particles were deposited first, resulting in material of somewhat coarser texture near the bluff line than farther back on the upland. The reader is therefore referred to the descriptions of the types mapped as Yellow-Gray Silt Loam (page 19) for descriptions of corresponding types mapped as Yellow-Gray Fine Sandy Loam and also for management suggestions.

Yellow Fine Sandy Loam (875)

Yellow Fine Sandy Loam is formed in the same way as Yellow Silt Loam. The two types differ but little except that immediately adjacent to the bluff line, where the former is found, the texture of the material is somewhat coarser than it is farther to the east. The reader is therefore referred to the discussion of Yellow Silt Loam on this page for further information about the character and use of this type.

Dune Sand (881)

Dune Sand is the coarse-textured material laid down by the wind in dune-like formations in certain places adjacent to the bluff line. It is of value for little else than pasture or timber and does not produce very good pasture. In

places where the topography permits, sweet-clover pasture may be established. Care must be used to control both wind and water erosion until the growing vegetation acts as a protection.

TERRACE SOILS

Yellow-Gray Silt Loam (1534)

Yellow-Gray Silt Loam, Terrace, occurs in small areas as bench-like formations along the small streams in the county. This type is very similar to the type described as No. 2 under Yellow-Gray Silt Loam (434), page 20, but differs in not having as good surface drainage. The reader is asked to turn to the above description and discussion for information regarding this terrace type.

Dune Sand (1581)

Dune Sand, Terrace, occurs between the bluffs and the Illinois river. It is a recent, wind-deposited formation and is of relatively low agricultural value. The surface 5 or 6 inches is very light brown sand, and immediately below this thin surface horizon the color becomes yellow or reddish yellow. The texture of the material is coarse and there is no subsoil development.

Management.—Dune Sand, Terrace, is drouthy, low in organic matter and nitrogen, and is subject to drifting by the wind where it is not protected by trees or other vegetation. It is a good watermelon soil but does not rank very high for general farming. The Oquawka experiment field is located on this kind of soil, and the reader is asked to turn to the results from this field and their discussion, page 62, for suggestions regarding the management of this soil.

SWAMP AND BOTTOM-LAND SOILS

This group includes the bottom land along the Illinois river and along the creeks of the county. These bottom lands are made up of soil material deposited from running water, and they vary in character with the source of the material deposited, the velocity of the stream flow at the time of the deposition, and drainage conditions since the material was deposited. The soils occurring in these areas vary in age, as indicated by different degrees of development of the horizons of the profiles. Some of the types mapped are of little importance because they occupy only a small area or are swampy.

Brown Silt Loam (1426)

Brown Silt Loam, Bottom, is mapped only in the Illinois bottom in Morgan county. It covers a total area of 3.26 square miles and is a productive type except where poorly drained. Considerable variation occurs in this soil, particularly in the subsurface and subsoil. The areas which are, or have been, poorly drained contain much gray and drab color in these horizons, while the areas which have developed under good drainage conditions show little gray or drab in the lower horizons. The horizons are imperfectly developed in this type and a general type description cannot be written because of the variations in color, texture, plasticity of the subsoil, and other features.

Management.—Brown Silt Loam, Bottom, is not acid except on the higher portions of the type, which are beginning to show a slight acidity. No fertilizer treatment is advised for this soil at the present time, but fresh organic matter should be provided by growing clover at regular intervals.

Black Clay Loam (1420)

Black Clay Loam, Bottom, is found only in the Illinois bottom in Morgan county. Drainage has been provided for much of this type by the construction of ditches, but the drainage is still poor on some areas. The type occupies a total of about 2 square miles. It has a clay loam surface and is drab or gray below 8 or 10 inches in depth. It is a productive soil, needs no lime, and requires only frequent additions of fresh organic matter to insure its continued productivity for many years to come.

Sandy Black Clay Loam (1420.1)

Sandy Black Clay Loam, Bottom, is of little importance in Morgan county because of its limited area. It is similar to the preceding type (1420) except that sufficient sand has become mixed with it to give it a sandy clay loam texture. This type is alkaline in places where it is so situated as to receive seepage water from the adjacent Dune Sand.

Drab Clay (1415)

Drab Clay, Bottom, is of little importance in Morgan county because of its small extent, less than one-half square mile, and because of its low agricultural value. It is poorly drained and no attempt should be made, under present conditions, to bring it under cultivation.

Brown Sandy Loam (1460)

Brown Sandy Loam, Bottom, aggregates a little over 2½ square miles in Morgan county and is located in the Illinois bottom. Portions of this type are swampy and other portions are under cultivation.

The surface soil of this type is light brown in color, and the lower portions of the profile are reddish yellow with little or no horizon development. The texture is sandy thruout the profile.

Management.—There is little encouragement for developing the swampy portions of the type, but the areas which are well drained may be farmed to advantage. Particular attention should be given to plowing down clover, preferably sweet clover, applying lime if necessary to grow this crop.

Brown Fine Sandy Loam (1471)

Brown Fine Sandy Loam, Bottom, is the most extensive type in the Illinois bottom. It covers a total of nearly 6 square miles. This soil is formed from material washed into the bottom from the adjacent bluffs and shows very little horizon development. The surface is light brown fine sandy loam. At a depth of about 7 inches, the color becomes somewhat yellowish and at a depth of about 20 inches a very imperfectly developed subsoil occurs. The youth of this soil, together with the good quality of the material from which it is formed, makes it

productive. It is easily worked, very permeable to plant roots, and either not acid or only slightly so.

Management.—Brown Fine Sandy Loam, Bottom, is well adapted to any of the general farm crops, and, with good farming, gives excellent yields. Particular attention should be given to returning leguminous organic matter to this soil as it is relatively low in nitrogen and organic matter. No fertilizer treatment is recommended for this soil at the present time.

Yellowish Brown Fine Sandy Loam (1479)

Yellowish Brown Fine Sandy Loam, Bottom, is closely related to the preceding type, Brown Fine Sandy Loam (1471). It is of the same origin and differs from it only in being younger, and therefore in having a lighter colored surface soil and less development of subsurface and subsoil horizons. It requires the same management as Brown Fine Sandy Loam.

Mixed Loam (1454)

Mixed Loam is very diverse in character. It is the most extensive bottomland type in Morgan county, aggregating a little over 31 square miles. It occurs, for the most part, along the creeks thruout the county. It consists of distinct types occurring in such small areas that they cannot be shown on the map and consequently they are all grouped together and called Mixed Loam. The texture of the surface varies from a sandy loam to a clay loam. The subsurface and subsoil vary in the same way as does the surface.

Management.—The diversity of Mixed Loam calls for different tillage methods where the extremes in the type occur. Some areas are so heavy as to require care in working them at the right moisture content, while others are very sandy. The type in general is not acid and needs only fresh organic matter and intelligent tillage.

Brown-Gray Silt Loam On Tight Clay (1428)

Brown-Gray Silt Loam On Tight Clay, Bottom, is of little importance in Morgan county. It occupies only 96 acres and is relatively low in agricultural value. It occurs in the Illinois bottom along the Cass county line. This soil was developed under conditions which resulted in the formation of a thick, impervious subsoil. The surface soil is grayish brown silt loam and the subsurface is more or less gray.

Brown-Gray Sandy Loam On Tight Clay (1468)

Brown-Gray Sandy Loam On Tight Clay is similar in properties and occurrence to Brown-Gray Silt Loam On Tight Clay, but it is somewhat lower in agricultural value. Only 160 acres occur in Morgan county.

Deep Peat (1401)

Only 13 acres of Deep Peat occur in Morgan county. It may be found on the map on the line between Sections 12 and 13, Township 16 North, Range 13 West.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items, such as native vegetation (whether timber or prairie), topography, and geological origin and formation, may assist in the differentiation of types, altho they are not fundamental to it.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a matured soil, three horizons designated as *A*, *B*, and *C* are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the *A* horizon.

C designates the layer lying below the *B* horizon and in which the material has been less affected by the weathering processes.

Frequently differences within a stratum or zone are discernible, in which case it is subdivided and described under such designations as A_1 and A_2, B_1 and B_2, etc.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in differentiating soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made wherever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of this report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their respective index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoian moraines,* including the moraines of the Illinoian glaciations
300 *Lower Illinoian glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoian glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoian glaciation,* covering about fourteen counties northwest of the middle Illinoian glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoian
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation

1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* formed by material derived from the Illinoian or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the remainder of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoian glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to the last of November. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction.

FIG. 5.—EXAMINING THE SOIL PROFILE

Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil

management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

Ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed

FIG. 6.—ALL ESSENTIAL PLANT-FOOD ELEMENTS MUST BE PRESENT

The jars in which these corn plants are growing contain pure sand to which have been added various combinations of the essential plant-food elements. If a single one of these elements is omitted, the plants cannot develop; they die after the small supply stored in the seed becomes exhausted.

from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants, which include only the clovers, peas, beans, and vetches among our common agricultural plants, are dependent upon the soil for the other six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bonemeal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5.
[2]Young second-year growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering

bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4_1 have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen usually costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils within a single season may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

FIG. 7.—LEGUMES CAN OBTAIN THEIR NITROGEN FROM THE AIR

The photograph tells the story of how clover benefits the soil. In the pot at the left all the essential plant-food elements, including nitrogen, are supplied. In the middle jar all the elements, with the single exception of nitrogen, are present. At the right nitrogen is likewise withheld but the proper bacteria are supplied which enable the clover to secure nitrogen from the air.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased only for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Superphosphate (acid phosphate) is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Besides phosphorus, superphosphate also contains sulfur, which is likewise an element of plant food. The phosphorus in superphosphate is more readily available for absorption by plants than that of raw rock phosphate. Superphosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate, and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of super-

phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of superphosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use under any given set of conditions.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using superphosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be remedied by the application of some potassium salt, such as potassium, sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that, with a few exceptions, the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium salts to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part, perhaps, by the fact that the potassium removed in the crops is mostly returned in manure properly cared for, and perhaps in larger part by the fact that decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no limiting element of plant food.

In considering the conservation of potassium on the farm it should be remembered that in average livestock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phophorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the

physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as

grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the corn is planted. Whether the crop be corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce. As a general principle the shorter rotations, with

the frequent introduction of leguminous crops, are the best adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)
Sixth year —Clover, or clover and grass

In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed; or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

The two following rotations are suggested as especially adapted for combating the corn borer:

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Corn (for silage)
Sixth year —Wheat (with sweet clover)

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Wheat (with alfalfa)
Sixth year —Alfalfa

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)
Fifth year —Clover

First year —Corn
Second year —Soybeans
Third year —Corn
Fourth year —Wheat (with legume)
Fifth year —Legume

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field rotating over all fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute barley or rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover, or it may include alfalfa used as a biennial. The mixing of alfalfa with clover seed for a legume crop is a recommendable practice. In connection with livestock production it may be desirable to mix grass with the clover for pasture or hay. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results From Experiment Fields on Soil Types Similar to Those Occurring in Morgan County)

The University of Illinois has operated altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the results from certain of these fields located on types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfafa, that crop being harvested for hay the same as in the livestock system. Some modifications have been introduced in recent years as will be explained in the descriptions of the respective fields.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grain to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the ***residues system.***

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated sP = superphosphate (acid phosphate), bP = bonemeal, rP = rock phosphate
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
Le = Legume used as green manure
Cv = Cover crop
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed

THE MT. MORRIS FIELD

The Mt. Morris experiment field was established in 1910 at Mt. Morris in Ogle county. The soil represents fairly well the type Light Brown Silt Loam, altho the plots are not althogether uniform in this respect. The plots considered here comprize four series under a rotation of corn, oats, clover, and wheat, with soil treatments as indicated in the accompanying table. The application of straw to the residues plots has been discontinued in these later years. In 1922 the application of limestone, and in 1923 the application of rock phosphate, were indefinitely suspended in order to observe the residual effect of these materials.

A summary of the results of the work is given in Table 7, in the form of the average annual crop yields for the years since the complete soil treatments have been in effect.

The outstanding results from these records are those produced by the manure treatment. Over 14 bushels of corn, over 9 bushels of oats, 4.7 bushels of wheat, and a half ton of clover have been the average annual acre increases in crop yields from the manure plots over the corresponding checks. Residues alone have

FIG. 8.—CORN ON THE MT. MORRIS FIELD

The two pictures represent the extremes in corn production on this field. Where the untreated land has produced as a fourteen-year average 44.6 bushels an acre, the land under the residues, limestone, phosphate, potash treatment has yielded 67.2 bushels. The most profitable treatment on this field, however, has been that of residues and limestone, which has produced 62.2 bushels an acre.

TABLE 7.—MT. MORRIS FIELD: SUMMARY OF CROP YIELDS

Average Annual Fields 1913-1927—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *13 crops*	Corn *15 crops*	Oats *15 crops*	Clover *12 crops*	Soybeans *2 crops*
1	0	22.8	44.4	57.7	(1.94)	(1.56)
2	M	27.5	59.0	67.1	(2.54)	(1.70)
3	ML	33.6	64.1	70.6	(2.96)	(1.80)
4	MLP	35.0	63.7	71.5	(2.89)	(1.92)
5	0	23.0	43.9	54.2	(1.65)	(1.34)
6	R	24.8	50.7	58.5	(1.70)	(1.60)
7	RL	32.0	62.2	68.2	(2.20)	(1.89)
8	RLP	35.2	65.5	69.9	(2.21)	(2.07)
9	RLPK	35.4	66.9	70.2	(2.24)	(2.00)
10	0	24.1	42.9	51.9	(1.61)	(1.68)
	Crop Increases					
	M over 0	4.7	14.6	9.4	(.60)	(.14)
	R over 0	1.8	6.8	4.3	(.05)	(.26)
	ML over M	6.1	5.1	3.5	(.42)	(.10)
	RL over R	7.2	11.5	9.7	(.50)	(.29)
	MLP over ML	1.4	− .4	.9	−(.07)	(.12)
	RLP over RL	3.2	3.3	1.7	(.01)	(.18)
	RLPK over RLP	.2	1.4	.3	(.03)	−(.07)

also produced increases in the crop yields altho the effect is much less pronounced than that of manure alone.

Limestone has been profitably used in both the manure and residues systems but the benefit has been greater in the residues system.

The rock phosphate, as usual, has been somewhat more effective used with residues than with manure, but under present market conditions and used in the quantity employed in these experiments, it has thus far not returned its costs, even with residues. However, as noted above, applications of phosphate have been suspended and the residual effect of the accumulated phosphorus in the soil during the years to come will be awaited with interest.

No significant effect is apparent from potassium as used in these experiments.

THE DIXON FIELD

A summary of the results from the Dixon experiment field are presented here, inasmuch as the soil of this field is similar to some of that found in Morgan county. This field includes about 21 acres and is laid out into two general systems of plots, a major and a minor system. The results from the major system will be considered here.

The rotation practiced has been wheat, corn, oats, and clover. The treatment of the plots and management of the crops were, for the most part, maintained up to 1922 according to the general plan described on pages 43 and 44. The most important modification of the plan has been the discontinuance, within the last few years, of the applications of limestone, phosphate, and straw residues.

TABLE 8.—DIXON FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1912-1927—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *12 crops*	Corn *16 crops*	Oats *15 crops*	Barley *1 crop*	Clover *10 crops*	Soybeans *4 crops*
1	0	20.4	36.3	48.3	43.3	(1.71)	(1.46)
2	M	26.6	55.3	61.5	46.4	(2.45)	(1.78)
3	ML	30.2	59.8	64.8	55.2	(2.70)	(1.92)
4	MLP	33.4	62.3	66.6	58.3	(2.83)	(1.97)
5	0	21.4	41.9	53.5	49.5	(1.41)	(1.18)
6	R	24.2	49.8	57.6	53.8	(1.49)	(1.35)
7	RL	27.4	56.3	61.4	54.5	(1.79)	(1.35)
8	RLP	32.0	57.6	64.1	59.0	(2.04)	(1.33)
9	RLPK	32.9	61.1	63.6	56.9	(2.21)	(1.15)
10	0	19.8	40.5	50.8	45.4	(1.81)	(1.45)
	Crop Increases						
	M over 0	6.2	19.0	13.2	3.1	(.74)	(.32)
	R over 0	2.8	7.9	4.1	4.3	(.08)	(.17)
	ML over M	3.6	4.5	3.3	8.8	(.25)	(.14)
	RL over R	3.2	6.5	3.8	.7	(.30)	(0.00)
	MLP over ML	3.2	2.5	1.8	3.1	(.13)	(.05)
	RLP over RL	4.6	1.3	2.7	4.5	(.25)	−(.02)
	RLPK over RLP	.9	3.5	− .5	−2.1	(.17)	−(.18)

FIG. 9.—CLOVER ON UNTREATED LAND, DIXON FIELD

A cutting of red-clover hay obtained from an untreated plot. Compare with the crop shown in Fig. 10.

Table 8 gives a summary of the results in terms of the average annual crop yields obtained since the plots have been under complete treatment.

In considering these results, the most striking feature to be observed is the outstanding effect of farm manure (M). The average annual increase due to the use of manure alone has amounted to 19 bushels of corn an acre, more than 13 bushels of oats, over 6 bushels of wheat, ¾ of a ton of clover, and ⅓ of a ton of soybean hay.

FIG. 10.—CLOVER ON TREATED LAND, DIXON FIELD

A cutting of red-clover hay produced under the residues-limestone-phosphate treatment. Here we have a yield of 1,319 pounds, more than two and one-third times the yield on the untreated land.

Organic manure in the form of crop residues (R) has also produced increases in yields altho not to the extent of those produced by animal manure.

Limestone (L) in addition to organic manures has, with a single exception, effected more or less improvement, probably sufficient to cover the expense of application.

Rock phosphate (P), as usual, shows up to best advantage when used with residues on the wheat crop. The effect on other crops, however, has been such that the increases in yield are not sufficient to cover the cost of the application under existing market conditions.

Altho potassium (K) has produced an average increase of 3.5 bushels an acre in corn, the effects on other crops are such as to render its use unprofitable in growing these common field crops.

THE KEWANEE FIELD

Experiments on the Major Series

The Kewanee field, located in Henry county, represents in the main the soil type Brown Silt Loam, altho a draw traversing the field in a winding direction contains a narrow streak of a heavier type designated as Black Clay Loam On Drab Clay. The Kewanee field has been in operation since 1915. The crops grown on the main series of plots are wheat, corn, oats, and clover. The arrangement of plots as well as the systems of soil treatment are indicated in Table 9.

TABLE 9.—KEWANEE FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1917-1927—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *9 crops*	Corn *11 crops*	Oats *11 crops*	Clover *10 crops*
1	0	30.0	53.9	59.4	(1.64)
2	M	33.6	65.0	70.3	(2.26)
3	ML	35.8	68.7	73.0	(2.30)
4	MLP	40.7	70.0	71.2	(2.46)
5	0	31.8	54.5	60.6	(1.60)
6	R	33.3	56.7	59.2	(1.55)
7	RL	35.3	64.9	61.9	(1.78)
8	RLP	40.9	69.5	68.2	(1.98)
9	RLPK	41.2	73.0	70.1	(2.03)
10	0	29.4	49.7	56.6	(1.38)
	Crop Increases				
	M over 0	3.6	11.1	10.9	(.62)
	R over 0	1.5	2.2	− 1.4	−(.05)
	ML over M	2.2	3.7	2.7	(.04)
	RL over R	2.0	8.2	2.7	(.23)
	MLP over ML	4.9	1.3	− 1.8	(.16)
	RLP over RL	5.6	4.6	6.3	(.20)
	RLPK over RLP	.3	3.5	1.9	(.05)

The table gives a summary of the crop yields by annual averages, including the years since the complete soil treatments have been in effect. In the lower part of the table the comparisons expressed as crop increases resulting from the respective soil treatments bring out the following points of interest.

Animal manure (M) used alone has had a very beneficial effect, especially with corn, oats, and clover. Residues alone (R) have had little effect on crop yields.

Limestone (L) used in addition to organic manures appears to have effected more or less improvement in all cases altho where used with animal manure on the clover the increase is scarcely significant.

Phosphorus (P) shows up to advantage on the wheat crop, and in the residues system the rock phosphate has produced a profitable return. A fact which these general averages fail to show is that with both limestone and phosphate the effects have been more favorable in recent years than in the earlier years of the experiments.

Altho an increase of 3.5 bushels of corn appears as a result of potassium (K) application, in view of the insignificant response by the other crops the purchase of potassium fertilizer for use in this kind of a cropping system on this kind of soil would appear not to be profitable.

Experiments on the Minor Series

In addition to the experiments described above, the same rotation is being conducted on a smaller series of plots where a comparison of rock phosphate and superphosphate (acid phosphate) is being made.

Alfalfa was grown on these plots until 1922. In the beginning, limestone was applied to Plots 3 and 4 at the rate of 4 tons an acre. This application was repeated in 1919. In 1922 the present experiments with phosphates were begun, and the same rotation as practiced on the larger series was established on these series. In this phosphate comparison rock phosphate was used on Plots 1 and 3 at the annual rate of 400 pounds an acre, applied once in the rotation ahead of the wheat; but beginning with 1927 rock phosphate has been applied at the same time as the superphosphate. Superphosphate is used on Plots 2 and 4 and at the annual rate of 200 pounds an acre. It is applied twice in the rotation, one-half for wheat and one-half for oats. A summary of the annual crop yields and their values are given in Table 10.

TABLE 10.—KEWANEE FIELD: PHOSPHATE EXPERIMENT
Average Annual Yields and Corresponding Money Values 1922-1927
Bushels or (tons) per acre

Soil treatment	Wheat *6 crops*	Corn *6 crops*	Oats *6 crops*	Hay *6 crops*	Value per acre
Rock phosphate	44.7	71.7	75.6	(3.50)	$45.41
Superphosphate[1]	47.1	70.9	78.4	(3.44)	46.06
Limestone, rock phosphate	40.7	69.1	74.4	(3.52)	43.72
Limestone, superphosphate[1]	47.8	70.3	76.7	(3.61)	46.60

[1]Acid phosphate.

The difficulty of arriving at a general conclusion regarding the comparative economy in the use of these different phosphorus materials is obvious, for all depends upon their relative cost, which fluctuates from time to time. Furthermore, the prices received from farm produce likewise fluctuate; and to complicate matters still further these fluctuations do not necessarily run parallel with those of the fertilizer cost. However, one may readily compute for himself the relative economy of producing these crop increases by applying any set of prices for crops and fertilizers which appear to be most applicable according to prevailing market conditions.

For this purpose the following set of prices are assumed as representing the average market conditions for the past six years (December 1 quotations): wheat, $1.20 a bushel; corn, 68 cents; oats, 40 cents; and hay, $14.00 a ton. For the cost of the two phosphorus carriers, an estimate of $12 a ton for rock phosphate and $24 a ton for superphosphate may be taken, thus making the expense for the two kinds of phosphate equal.

Applying these prices to the yields given in Table 10, it appears that, of the four different tests, the highest average annual gross return, $46.60, was given by the superphosphate with limestone. Upon adding the limestone, the return from superphosphate was increased by only 54 cents an acre, thus indicating that the purchase of limestone for this combination was unprofitable. The returns from rock phosphate with limestone were $1.69 an acre less than those from rock phosphate alone. Thus of the treatments included in this test the most profitable lies in one of the two forms of phosphates used alone, and the results thus far show a greater gross return per acre of 65 cents in favor of the superphosphate.

It is of interest to note that wheat has been the crop most affected by the form of phosphate applied. It is to be borne in mind that the order of values can easily be shifted by a change in relative yields of the respective crops or by a change in commodity prices. Furthermore, no consideration has been given here to any possible difference in residual effects of the two forms of phosphate, which might appear upon discontinuing the treatments.

THE BLOOMINGTON FIELD

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat; and since 1905, they have been grown in the sequence named.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. The phosphorus on this field has been supplied in the form of steamed bone meal at the rate of 200 pounds an acre a year.

Table 11 presents a summary of the work to 1923 by average annual yields. The comparisons in the lower part of the table show the effect of the different plant-food materials in the combinations in which they have been applied.

TABLE 11.—BLOOMINGTON FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1902-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*	Clover[1] *3 crops*
1	0	44.6	40.6	26.5	(.74)
2	L	41.5	44.7	24.1	(.80)
3	LR	47.5	46.2	27.9	(.88)
4	LbP	55.8	54.3	45.7	(2.54)
5	LK	46.2	43.5	25.5	(.90)
6	LRbP	60.6	66.0	49.7	(1.19)
7	LRK	48.6	46.8	27.5	(.82)
8	LbPK	60.9	57.2	44.5	(2.44)
9	LRbPK	64.2	63.1	50.4	(.81)
10	RbPK	58.8	52.8	49.3	(.83)
	Crop Increases				
For limestone					
L	over 0	− 3.5	4.1	− 2.4	(.06)
LRbPK	over RbPK	5.4	10.3	1.1	−(.02)
For residues					
LR	over L	6.0	1.5	3.8	(.08)
LRbP	over LbP	4.8	11.7	4.0	−(1.35)
LRK	over LK	2.4	3.3	2.0	−(.08)
LRbPK	over LbPK	3.3	5.9	5.9	−(1.63)
For phosphorus					
LbP	over L	14.3	9.6	21.6	(1.74)
LRbP	over LR	13.1	19.8	21.8	(.31)
LbPK	over LK	14.7	13.7	19.0	(1.54)
LRbPK	over LRK	15.6	16.3	22.9	−(.01)
For potassium					
LK	over L	4.7	− 1.2	1.4	(.10)
LRK	over LR	1.1	.6	− .4	−(.06)
LbPK	over LbP	5.1	2.9	− 1.2	−(.10)
LRbPK	over LRbP	3.6	− 2.9	.7	−(.38)

[1]Two crops of seed on Plots 3, 6, 7, and 9 are evaluated as hay.

The value of limestone (L) on this field is difficult to assess on account of the erratic results found upon comparing Plots 1 and 2. Here both corn and wheat appear to have suffered from the application of limestone, but the difficulty may well be attributable to soil variability. Comparing Plots 9 and 10 it would appear that in combination with residues, phosphorus, and potassium, the limestone on the whole has been beneficial.

The residues treatment (R) supplying organic matter and nitrogen, shows a beneficial effect on the grain crops, but not on the clover.

The prominent feature of the results on the Bloomington field is the effect of phosphorus applied in the form of steamed bone meal (bP). In all the grain crops on every plot where bone meal has been applied there is a remarkable response to the treatment, as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues with limestone, residues, and phosphorus) we find the phosphorus treatment has produced an average increase in the yield of corn of about 13 bushels an acre, while the yield

of oats has been increased by about 20 bushels, and that of wheat by about 22 bushels an acre. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8 where potassium instead of residues is present.

Quite different are the results from the use of potassium (K) on this field. The potassium has been applied mainly in the form of potassium sulfate, but in 1917 when this material became unavailable thru war conditions, potassium carbonate was substituted. There is a moderate increase in the corn yield where potassium has been used and particularly where residues are absent. Otherwise, the small gain shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is the outstanding limiting factor in production and the application of this element in the form of steamed bone meal is attended by a high financial profit.

In view of this remarkable response to bone meal on the Bloomington field, it was of interest to know how other carriers of phosphorus would behave, and accordingly some experiments were planned to investigate this question. For this purpose the plots were divided in 1924, and certain new treatments were applied in order to compare the effects of rock phosphate and of superphosphate (acid phosphate) with bone meal, and at the same time to determine the residual effect of the accumulated phosphorus resulting from its continuous application in presumably somewhat excessive amounts. Table 12 indicates the arrangement of these new treatments and also gives the results of the four years in which these later experiments have been in progress.

In arriving at the financial results presented in the table, the values of the crops are based upon December 1 farm price quotations for the years in which the respective crops were produced. In deducting the annual cost for the different treatments, the total amounts of materials applied during the entire period of operation on the field were prorated. The expense for limestone is reckoned here at $3 a ton, rock phosphate at $14, superphosphate at $28, bone meal at $48, and residues at 75 cents an acre.

In considering the results it should be borne in mind that they are based upon only four years' experience, a rather short period for drawing final conclusions in this sort of experimentation; also that the soil of these plots is somewhat variable, with little provision for duplication; and that some of the treatments are not now strictly comparable with one another on account of the previous treatment of the plots. Nevertheless, making allowances for all of these facts, certain figures in the last column of the table indicate effects worthy of consideration.

In answering the question whether other carriers of phosphorus would be as effective as the bone meal in building up this soil, attention is called to the results on Plots 2-N, 3-N, and 3-S, where bone meal, rock phosphate, and superphosphate (acid phosphate) respectively have been employed in addition to limestone and residues. Unfortunately the comparison here is not altogether perfect in that the residues treatment on Plot 2-N was not introduced until 1924, whereas the other two plots had been under residues in the old system

TABLE 12.—BLOOMINGTON FIELD: NEW PHOSPHATE EXPERIMENTS
Crop Yields and Values 1924-1927—Bushels or (tons) and dollars per acre

Serial plot No.	Treatment		1924	1925	1926	1927	Average annual acre values		
	Previous	Present	Oats	Clover	Wheat	Corn	Gross	Cost of treatment	Net
1-N	0	R	60.6	(.79)	29.3	49.8	$28.09	$ .75	$27.29
1-S	0	0	58.4	(2.54)	19.5	41.0	30.18	.....	30.18
2-N	L	RLP (bone)	72.6	(1.63)	35.0	58.6	36.09	6.55	29.54
2-S	L	RL	53.2	(.75)	18.7	46.0	22.85	1.75	21.10
3-N	RL	RLP (rock)	68.2	(2.18)	32.5	63.6	37.88	5.25	32.63
3-S	RL	RLP (super)	71.3	(1.74)	41.0	67.6	39.80	4.55	35.25
4-N	LP (bone)	RLP (bone)[1]	57.6	(1.81)	37.3	60.0	35.74	7.75	27.99
4-S	LP (bone)	RLP (bone)[2]	67.2	(1.89)	36.7	63.6	37.89	5.35	32.54
5-N	LK	RLKP (rock)	63.2	(1.66)	32.5	61.4	34.83	7.54	27.29
5-S	LK	RLKP (super)	78.4	(1.59)	40.7	69.4	40.26	6.84	33.42
6-N	RLP (bone)	RLP (bone)[1]	68.8	(2.18)	40.5	60.8	39.89	7.75	32.14
6-S	RLP (bone)	RLP (bone)[2]	71.6	(2.21)	40.0	64.2	40.79	5.35	35.44
7-N	RLK	RLKP (rock)	71.2	(2.11)	35.3	66.4	39.30	7.54	31.76
7-S	RLK	RLKP (super)	80.9	(1.66)	40.7	74.8	41.79	6.84	34.95
8-N	LKP (bone)	RLKP (bone)[1]	60.9	(1.69)	39.2	67.4	37.79	10.04	27.75
8-S	LKP (bone)	RLKP (bone)[2]	65.0	(1.59)	36.0	69.4	37.25	7.64	29.61
9-N	RLKP (bone)	RLKP (bone)[1]	60.9	(2.18)	43.8	75.8	42.63	10.04	32.59
9-S	RLKP (bone)	RLKP (bone)[2]	72.2	(1.65)	41.5	77.8	41.51	7.64	33.87
10-N	RKP (bone)	RKP (bone)[1]	48.2	(1.93)	45.7	56.6	37.32	9.04	28.28
10-S	RKP (bone)	RKP (bone)[2]	51.2	(1.53)	43.0	60.6	35.97	6.64	29.33
11-N	[3]	RP (rock)	70.4	(1.68)	45.3	61.8	39.74	4.25	35.49
11-S	[3]	RP (super)	60.0	(1.78)	44.5	63.0	38.88	3.55	35.33

[1]Bone meal applications resumed in 1924. [2]No bonemeal applied since 1917. [3]New plot added in 1924.

before the present experiments were begun and may therefore have an advantage over the bone meal plot. However this may be, the results as they stand place both rock phosphate and superphosphate ahead of bone meal.

It is interesting to observe that in the three plots giving the very highest net return (Plots 6-S, 11-N, and 11-S) all three forms of phosphate—bone meal, rock phosphate, and superphosphate—are represented in the respective treatments and the differences among the results are so small as to be negligible.

Between rock phosphate and superphosphate four direct comparisons under varying conditions are afforded. On the new plots, 11-N and 11-S, no limestone has been applied and here the difference in the net returns from the two forms of phosphate is insignificant.

In the other comparable tests between rock phosphate and superphosphate (Plots 3, 5, and 7) limestone is used in the combination, and in each case the superphosphate has given the higher net return. Thus, as is so often the case, limestone appears to exert a depressing effect upon the efficiency of rock phosphate. In the final result, however, the simpler system of residues and phosphate appears to be fully as effective, so far as net value of crops per acre is con-

cerned, as the more complex systems in which limestone or limestone and potassium are included.

On the whole, therefore, the data of these four years appear to furnish no conclusive evidence for discriminating among the three forms of phosphate.

For light on the question of residual effect of accumulated phosphorus in the soil, attention is called to the results on Plots 4, 6, 8, 9, and 10, where the north half-plots are now regularly receiving bone meal, while the south halves have received none since 1917. Invariably the net return is higher on the south half, thus indicating that the reserve phosphate accumulated in the soil from previous applications is still exerting a beneficial effect that is more than adequate to offset the expense involved in renewed applications.

By way of summarizing the main lessons brought out by the Bloomington experiments, the following statements may be made.

1. The results indicate an outstanding phosphorus hunger.
2. This phosphorus need is satisfied by the application of either bone meal, rock phosphate, or superphosphate.
3. So far as the data from these particular experiments are concerned, there is no indisputable evidence for discrimination among these three carriers.
4. On these plots there is a pronounced residual effect from previous excessive applications of bone meal.

THE ALEDO FIELD

An experiment field on Brown Silt Loam On Clay is located in Mercer county just west of Aledo. This field has been in operation since 1910. From its physical aspects this field should be well adapted to experimental work, the land being unusually uniform in topography and in soil profile.

There are two general systems of plots and they are designated as the major and the minor systems.

Experiments on the Major Series

The major system comprizes four series made up of 10 plots each. The plots were handled substantially as described above for standard treatment until 1918, when it was planned to harvest the first crop of red clover on the residues plots for hay and to plow down the second crop if no seed were formed. In 1921 the return of the oat straw was discontinued. In 1923 the rotation was changed to corn, corn, oats, and wheat. In this rotation it was planned to seed hubam clover in the oats on all plots, for use as hay or for soil improvement, and common sweet clover in the wheat on the residues plots for use as a green manure. Since these changes, no residues except cornstalks and the green manure have been returned to the residues plots. The limestone applications were temporarily abandoned in 1923. No more will be applied until there appears to be a need for them. The phosphate applications were evened up to a total of 4 tons an acre in 1924, and no more will be applied on the west halves of these plots for some time at least.

Table 13 presents a summary of the results showing the average annual yields obtained for the period beginning when complete soil treatment came into

TABLE 13.—ALEDO FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1912-1927—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *13 crops*	Corn *21 crops*	Oats *15 crops*	Clover *6 crops*	Soybeans *3 crops*	Stubble clover[1] *1 crop*
1	0	30.0	55.8	57.6	(2.21)	(1.60)	(0.00)
2	M	34.7	69.6	64.7	(2.74)	(1.63)	(0.00)
3	ML	35.0	73.7	67.7	(3.12)	(1.60)	(1.65)
4	MLP	36.7	74.9	68.1	(3.05)	(1.61)	(1.71)
5	0	30.7	58.2	59.7	(2.00)	(1.61)	(0.00)
6	R	31.4	64.3	60.7	(1.91)	(1.65)	(0.00)
7	RL	33.7	71.6	66.1	(1.79)	(1.88)	(1.20)
8	RLP	37.7	74.1	67.4	(2.08)	(2.03)	(1.25)
9	RLPK	37.3	75.4	69.7	(1.73)	(2.09)	(1.57)
10	0	30.1	55.9	58.0	(2.38)	(1.62)	(0.00)
	Crop Increases						
	M over 0	4.7	13.8	7.1	(.53)	(.03)	(0.00)
	R over 0	.7	6.1	1.0	−(.09)	(.04)	(0.00)
	ML over M	.3	4.1	3.0	(.38)	−(.03)	(1.65)
	RL over R	2.3	7.3	5.4	−(.12)	(.23)	(1.20)
	MLP over ML	1.7	1.2	.4	−(.07)	(.01)	(.06)
	RLP over RL	4.0	2.5	1.3	(.29)	(.15)	(.05)
	RLPK over RLP	− .4	1.3	2.3	−(.35)	(.06)	(.32)

[1]Hubam clover was grown on Plots 3 and 4, biennial white sweet clover on Plots 7, 8, and 9.

sway. The lower section of this table gives comparisons in terms of crop increases intended to indicate the effect of the different fertilizing materials applied.

In looking over these results we may observe first the beneficial effect of animal manure on all crops, but especially marked on the corn. This suggests the advisability of carefully conserving and regularly applying all stable manure produced on the farm. Residues alone have been beneficial for corn but have shown little effect on the other crops of the rotation.

Limestone has been more effective applied with residues than with manure. An interesting fact not brought out in these averages is that the beneficial effect has increased in the later years.

The addition of rock phosphate to the treatment has had very little effect in the manure system. Somewhat more favorable are the results in the residues system, but even here the margin of profit on these crop increases is too narrow to assure the profitable use of rock phosphate applied in the manner of these experiments. However, the economic story has not all been told, for the application of lime and phosphate on these plots has been discontinued in order to observe the residual effects, and the results of the next few years, will be awaited with great interest.

For the effect of potassium treatment (K) Plots 8 and 9 may be compared. No significant response appears as the result of applying potassium, so far as these common field crops show.

A number of problems have arisen out of the experience on this and other experiment fields which call for some revision of the investigations described

above, and accordingly certain changes have been made in the conduct of these plots which are intended especially to throw more light upon the problems of liming and applying phosphorus. (See Soil Report No. 29).

Special Phosphate Experiments

The so-called minor system of plots on the Aledo field is given over to a comparison of the effectiveness of different carriers of phosphorus.

In this experiment each series contains four plots. Plot 1 receives residues treatment only; Plot 2 receives residues and phosphorus in one of the forms under test; Plot 3 receives residues, limestone, and phosphorus; and Plot 4 is similar to Plot 3 with phosphorus omitted. On one series steamed bone meal is used as the carrier of phosphorus and is applied at the rate of 200 pounds per acre per year. On another series superphosphate (acid phosphate) is applied at the yearly rate of 333⅓ pounds per acre. On a third series rock phosphate serves as the source of phosphorus, applied at the rate of 666⅔ pounds per acre yearly, and on the last series, basic slag phosphate is applied at the rate of 250 pounds per acre yearly.

A summary of the yields on these plots is given in Table 14. The differences in crop yields presumed to have resulted from applying the various forms of phosphatic fertilizers will be found in Table 15 for the twelve crops harvested since the beginning of the applications up to 1927. In computing these comparisons each phosphate plot is compared with its neighboring non-phosphate plot.

Aside from the soybeans, the figures show without exception more or less crop increase on the phosphorus plots, no matter what the form of carrier employed.

TABLE 14.—ALEDO FIELD: PHOSPHATE EXPERIMENT
General Summary—Average Annual Yields 1916-1927
Bushels or (tons) per acre

Plot No.	Soil treatment applied	Wheat *2 crops*	Corn *5 crops*	Oats *3 crops*	Clover *1 crop*	Soybeans[1] *1 crop*
501	R	38.2	60.4	66.1	(2.88)	18.9
502	R, bone meal	47.0	72.0	76.2	(3.25)	19.0
503	RL, bone meal	48.8	73.9	72.4	(3.48)	23.2
504	RL	38.8	68.0	64.2	(2.61)	22.6
601	R	38.1	61.1	67.6	(3.17)	19.5
602	R, superphosphate[2]	49.4	69.6	74.9	(3.23)	18.7
603	RL, superphosphate[2]	51.3	72.4	71.3	(3.53)	23.1
604	RL	40.0	66.7	65.3	(3.06)	24.6
701	R	39.5	62.8	67.5	(3.41)	20.8
702	R, rock phosphate	48.0	71.6	72.2	(3.60)	23.3
703	RL, rock phosphate	47.1	72.5	67.4	(3.82)	28.1
704	RL	41.4	68.8	65.6	(3.15)	26.9
801	R	39.8	60.2	57.9	(2.62)	18.0
802	R, slag phosphate	49.1	69.4	73.4	(3.66)	20.6
803	RL, slag phosphate	52.2	72.4	67.5	(3.63)	23.7
804	RL	40.8	65.0	63.7	(2.99)	21.8

[1]No residues were applied for this crop. [2]Acid phosphate.

TABLE 15.—ALEDO FIELD: AVERAGE ANNUAL CROP INCREASES PRODUCED BY THE VARIOUS FORMS OF PHOSPHATE, AND THEIR VALUE, COMPUTED FROM YIELDS IN TABLE 14

Bushels or (tons) per acre

Comparison of treatments	Wheat *2 crops*	Corn *5 crops*	Oats *3 crops*	Clover *1 crop*	Soybeans *1 crop*	Value of increase *12 crops*	Cost of phosphate *12 years*	Profit from *12 crops*	Profit per acre per year
Bone meal, residues, *over* residues	8.8	11.6	10.1	(.37)	.1	$78.02	$48	$30.02	$2.50
Bone meal, residues, lime, *over* residues, lime	10.0	5.9	8.2	(.87)	.6	66.97	48	18.98	1.58
Superphosphate[1], residues, *over* residues	11.3	8.5	7.3	(.06)	— .8	64.42	48	16.42	1.37
Superphosphate[1], residues, lime, *over* residues, lime	11.3	5.7	6.0	(.47)	— 1.5	58.03	48	10.03	.84
Rock phosphate, residues, *over* residues	8.5	8.8	4.7	(.19)	2.5	62.37	48	14.37	1.20
Rock phosphate, residues, lime, *over* residues, lime	5.7	3.7	1.8	(.67)	1.2	39.60	48	— 8.40	— .70
Slag phosphate, residues, *over* residues	9.3	9.3	15.5	(1.04)	2.6	91.00	30	61.00	5.08
Slag phosphate, residues, lime, *over* residues, lime	11.4	7.4	3.8	(.64)	1.9	68.89	30	38.89	3.24

[1]Acid phosphate.

Attention has already been called to the difficulties in making exact comparisons of this nature on account of fluctuating prices of both farm products and fertilizer materials. However, a set of arbitrary prices may be assumed and for the present purpose values similar to those used in calculating the results from the Kewanee field will be employed. In the following comparisons, wheat is placed at $1.20 a bushel; corn, at 68 cents; oats, at 40 cents; soybeans, at $1.50; and hay at $14 a ton. For the cost of the phosphatic materials, the following estimates are used: bone meal, $40 a ton; superphosphate (acid phosphate), $24; rock phosphate, $12; and slag phosphate, $20. These values seem to be conservative enough, and furthermore, it may be pointed out that the quantities of phosphatic fertilizer employed in these experiments are, with the possible exception of slag phosphate, greater than ordinarily would be used, or need be used, in good farm practice.

The total value of all crop increases for the twelve years is shown in Table 15, as is also the total cost of the phosphates applied and from these figures are derived the average annual acre profits shown in the last column of the table.

Reckoned on the basis of the above prices, it appears that the slag phosphate has furnished the most profitable returns of the four phosphorus carriers in the test, producing an average profit of $5.08 an acre yearly where applied without limestone, and $3.24 where applied with limestone. Bone meal has given an average profit of $2.50 applied without limestone and $1.58 applied with limestone. Superphosphate (acid phosphate) has returned $1.37 used without limestone and 84 cents used with limestone. Rock phosphate has produced the

lowest money returns, giving a profit of $1.20 an acre a year applied without limestone and a loss of 70 cents used with limestone.

No consideration is given here to the relative phosphorus reserves which should have accumulated in the soil. In considering these figures let it be emphasized again that the order of these values might easily be shifted by a relatively small change in commodity prices.

We may next consider the results from the standpoint of limestone, which was applied at the rate of 4 tons an acre to Plots 3 and 4 of the minor series in 1912, when the land was still under alfalfa. Another dressing of 2 tons an acre was added in 1917, after the present experiments were under way. The effect of this limestone, in terms of crop increase, is set forth in Table 16.

In estimating the financial results for the use of limestone, it is to be noted that altho 6 tons an acre have been applied in the last sixteen years, only the last 12 crops are involved in these particular experiments. For the present purpose, therefore, it may be considered that three-quarters of the total amount applied, or 4½ tons, is chargeable to the 12 crops under consideration. At the rate of $2 a ton the cost of the limestone, is therefore $9, to be charged against the value of the total crop increases for the twelve years included in this experiment. Figured in this manner we find a profit of $1.73 an acre a year for limestone applied without phosphate of any kind. Where limestone was applied with bone meal, the limestone profit was 56 cents an acre a year, and with superphosphate (acid phosphate) it was 96 cents. Used with rock phosphate, the crop increases were so small that a loss of 30 cents an acre a year was sustained, and with slag phosphate there was a gain of 48 cents an acre a year.

In view of the possible experimental error which is always involved in plot experiments of this sort, these margins of profit cannot be considered very

TABLE 16.—ALEDO FIELD: AVERAGE ANNUAL CROP INCREASES PRODUCED BY LIMESTONE AND THEIR VALUE, COMPUTED FROM YIELDS IN TABLE 14

Bushels or (tons) per acre

Comparison of treatments	Wheat *2 crops*	Corn *5 crops*	Oats *3 crops*	Clover *1 crop*	Soybeans *1 crop*	Value of increase *12 crops*	Cost of limestone *12 years*	Profit from *12 crops*	Profit per acre per year
Limestone, residues, *over* residues	1.4	6.0	− .1	−(.07)	4.7	$29.71	$9	$20.71	$1.73
Limestone, residues, bone meal, *over* residues, bone meal	1.8	1.9	− 3.8	(.23)	4.2	15.74	9	6.74	.56
Limestone, residues, superphosphate[1], *over* residues, superphosphate[1]	1.9	2.8	− 3.6	(.30)	4.4	20.54	9	11.54	.96
Limestone, residues, rock phosphate, *over* residues, rock phosphate	− .9	.9	− 4.8	(.22)	4.8	5.42	9	− 3.58	− .30
Limestone, residues, slag phosphate, *over* residues, slag phosphate	3.1	3.0	− 5.9	−(.03)	3.1	14.79	9	5.79	.48

[1]Acid phosphate.

pronounced. The Aledo field, however, represents one of those borderline cases, so to speak, in which the upper soil is only slightly acid and the lime requirement, therefore, is not yet very marked. As time goes on, however, and cropping continues, a greater need of lime may develop. It is planned to discontinue liming on these plots until its need becomes manifest, and in so doing the annual cost of the limestone already applied will become automatically reduced, so that net returns may possibly, sooner or later, become substantially increased.

THE HARTSBURG FIELD

A University soil experiment field representing Black Clay Loam is located in Logan county just east of Hartsburg. This field was established in 1911 and embraces 20 acres. The soil is uniform with the exception of a small area in the northwest part of the field which on the detailed map is identified as of the type Brown Silt Loam On Clay. A thoro system of tile has been installed whereby good drainage has been effected.

The somewhat standard rotation, including alfalfa and the soil treatment methods described on pages 43 and 44, were established on the five series of plots. These methods were followed without change until 1918, when it was planned to remove one hay crop and a seed crop of clover from the residues plots. In 1921 it was decided to harvest all the clover as hay. At that time the return of the oat straw was discontinued. In 1922 the return of the wheat straw was discontinued. The only residues plowed under since that time have been the cornstalks, and the green sweet clover before the corn. On this field the sweet clover has grown

TABLE 17.—HARTSBURG FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1913-1927—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Corn	Oats	Clover	Soybeans	Alfalfa	Stubble clover	
								Hubam	Common sweet clover
		13 crops	*22 crops*	*15 crops*	*7 crops*	*2 crops*	*8 crops*	*1 crop*	*1 crop*
1	0	24.9	48.4	46.1	(1.84)	(1.29)	(3.47)	(.83)	.....
2	M	29.2	58.0	51.6	(2.16)	(1.64)	(3.67)	(1.15)	.....
3	ML	34.0	64.2	57.4	(2.32)	(1.82)	(3.91)	(.91)	.....
4	MLP	36.2	63.4	56.8	(2.39)	(1.92)	(4.19)	(1.17)	.....
5	0	29.7	53.7	45.4	(1.28)	(2.58)	(3.33)	(.71)	.....
6	R	32.7	63.3	53.4	(1.67)	(2.68)	(3.78)	(.75)	(.85)
7	RL	30.1	66.8	51.6	(1.64)	(2.84)	(3.45)	(.68)	(.75)
8	RLP	34.3	66.8	55.1	(1.79)	(2.61)	(4.04)	(.72)	(.90)
9	RLPK	33.4	65.2	54.5	(1.70)	(2.64)	(4.16)	(.80)	(1.00)
10	0	30.5	52.7	47.1	(2.02)	(1.69)	(3.20)	(.75)	.....
	Crop Increases								
	M over 0	4.3	9.6	5.5	(.32)	(.35)	(.20)	(.32)	.....
	R over 0	3.0	9.6	8.0	(.39)	(.10)	(.45)	(.04)	.....
	ML over M	4.8	6.2	5.8	(.16)	(.18)	(.24)	−(.24)	.....
	RL over R	− 2.6	3.5	− 1.8	−(.03)	(.16)	−(.33)	−(.07)	−(.10)
	MLP over ML	2.2	− .8	− .6	(.07)	(.10)	(.28)	(.28)	.....
	RLP over RL	4.2	0.0	3.5	(.15)	−(.23)	(.59)	(.04)	(.15)
	RLPK over RLP	− .9	− 1.6	− .6	−(.09)	(.03)	(.12)	(.08)	(.10)

satisfactorily on the unlimed plots. The application of limestone was also discontinued in 1922 after amounts ranging from 7½ to 10 tons an acre on the different series had been applied, and no more will be added until further need for it becomes apparent. In 1923 the phosphate applications were evened up to 4 tons an acre on all plots, and no more will be applied for an indefinite period. At that time the rotation on Series 100, 200, 300, and 400 was changed to corn, corn, oats, and wheat, with a seeding of hubam clover in the oats on all plots, and a seeding of biennial sweet clover in the wheat on the residues plots. On Series 500 the rotation was changed to corn, oats, wheat, and a mixture of alfalfa and red clover for one year.

The outstanding feature of the results of the Hartsburg field is the large increase in yields produced by organic manures, whether they be in form of crop residues (R) or of stable manure (M).

The behavior of limestone (L) on this field presents a peculiarity difficult to explain in that limestone has been much more beneficial where applied with animal manure than where used with residues. With the exception of a single crop, limestone used with manure shows considerable increase and has given profitable returns on the investment, while in the residues system the effect of this material on several of the crops appears as negative and its use in this system has been attended by a financial loss.

Rock phosphate (P) has found its most effective place in these experiments in the production of wheat and of alfalfa, particularly in the residues system, but its effect on the other crops has been so indifferent that, on the whole, the use of this material has not proved profitable on this field.

The addition of potassium (K) in the combinations here employed has likewise been ineffective.

In 1924 these plots were divided and some new treatments designed to furnish further information regarding the effect of phosphorus fertilizers on this soil were introduced. The west halves were continued under the old treatments except that the phosphate applications were discontinued indefinitely after a total of 4 tons an acre of rock phosphate had been applied. These later experiments have scarcely continued long enough, however, to furnish results of sufficient reliability for discussion at this time.

THE VIENNA FIELD

Morgan county, as indicated in the descriptions of certain of its soil types, includes considerable land that is subject to destruction thru erosion or washing. Yellow Silt Loam, which occupies about 80 square miles in the county, is particularly susceptible to this kind of damage. Operators of land in Morgan county will therefore be interested in experiments conducted on the Vienna field, in Johnson county, to test out different methods of reclaiming badly gullied land and preventing further erosion.

The Vienna field is representative of the sloping, erodible land so common in the extreme southern part of the state. When the experiments were started the whole field, with the exception of about three acres, had been abondoned because so much of the surface soil had washed away, and there were so many gullies

FIG. 11.--PROPER SOIL AND CROPPING METHODS WOULD HAVE PREVENTED THIS CONDITION
This abandoned hillside is just over the fence from the field shown in Fig. 12. Yellow Silt Loam is particularly susceptible to this kind of damage.

that further cultivation was unprofitable. For the purpose of the experiments the field was divided into different sections (see Table 18). These were not entirely uniform; some parts were much more washed than others, and portions of the lower-lying land had been affected by soil material washed down from above. The higher land had a very low producing capacity; on many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except the one designated as D, which included but three plots.

FIG. 12.—CORN GROWING ON AN IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD
This land had formerly been badly eroded. It was reclaimed by proper soil treatment and cropping. Compare with Fig. 11.

TABLE 18.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields, 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

Section A included the steepest part of the field and contained many gullies. The land was built up into terraces at vertical intervals of 5 feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

Section B was used to test the so-called embankment method. Ridges were plowed up which were sufficiently high so that when there were heavy falls of rain the water would break over and run in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about 8 loads of manure an acre were turned under each year for the corn crop.

Section D was washed to about the same extent as Section C. It was farmed in the most convenient way, without any special effort to prevent washing.

Careful records were kept for nine years. The results, summarized in Table 18 indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels on the check series (D). Wheat yielded 11.1 bushels on the protected series, in comparison with 4.6 bushels on the check, and clover yielded ⅘ of a ton on the protected series and but ⅕ of a ton on the check.

Figs. 11 and 12 serve further to indicate what may be done with this type of soil even after it has become badly washed and gullied.

Altho these results show in principle the possibility of improving this land, it cannot be said that the experiments as conducted represent directly the most economical system of farming. However, it appears possible that by modifying the cropping plan in some manner, as for example, substituting sweet clover for cowpeas and giving large place in the farming system to hay and pasture crops, production might be substantially increased and thus a system of farming instituted that would represent a profitable enterprise.

THE OQUAWKA FIELD

Since there are considerable areas of Dune Sand, Terrace, in Morgan county, experiments on that type conducted by the University in Henderson county near the Mississippi river, will be of interest. The field was established in 1913. It is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted. Table 19

TABLE 19.—OQUAWKA FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1915-1927—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *13 crops*	Soybeans[1] *13 crops*	Wheat *13 crops*	Rye *11 crops*	Sweet clover[2] *9 crops*	Alfalfa *10 crops*
1	0	19.9	10.0	8.7	12.6	0.00	(.44)
2	M	25.4	12.0	12.0	14.5	0.00	(1.16)
3	ML	34.8	16.4	17.1	24.9	1.09	(2.49)
4	MLP	34.2	15.8	17.3	23.8	1.13	(2.57)
5	0	19.4	7.9	10.8	11.2	0.00	(.66)
6	R	21.1	8.3	12.5	11.6	0.00	(.72)
7	RL	36.6	12.0	16.1	24.0	1.43	(2.23)
8	RLP	36.4	12.7	16.6	24.0	1.32	(2.24)
9	RLPK	38.4	12.5	16.0	25.7	1.52	(2.29)
10	0	18.4	7.2	10.0	9.0	0.00	(.48)
	Crop Increases						
	M over 0	5.5	2.0	3.3	1.9	0.00	(.72)
	R over 0	1.7	.4	1.7	.4	0.00	(.06)
	ML over M	9.4	4.4	5.1	10.4	1.09	(1.33)
	RL over R	15.5	3.7	3.6	12.4	1.43	(1.51)
	MLP over ML	— .6	— .6	.2	— 1.1	.04	(.12)
	RLP over RL	— .2	.7	.5	0.0	— .11	(.01)
	RLPK over RLP	2.0	— .2	— .6	1.7	.20	(.05)

[1]Eleven regular crops, together with the extra crop described in the following footnote, averaged as 11 crops. Several crops which were harvested as seed are evaluated in this summary as hay.

[2]Some hay evaluated as seed. In 1918 the sweet clover was killed by early cutting for a hay crop. Soybeans were seeded in July and the ensuing crop is included in the soybean average.

indicates the kinds of treatment applied. The amounts of the materials used were in accord with the standard practice, as explained on pages 43 and 44.

Limestone (L), it will be noted, has had a remarkably beneficial action on this sand soil. Where it has been used in conjunction with crop residues, the yield of corn has been practically doubled. It has also produced good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite indifferent to treatment with rock phosphate (P). The analyses show, however, that the stock of phosphorus in this type of soil is not large; and as time goes on and the supply diminishes under the production of good-sized crops, the application of this element may become profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

The slight increases or decreases from the use of potassium (K) can scarcely be considered significant.

A significant fact which the above summary does not bring out is that improvement in crop yields under favorable treatment has been progressive, as evidenced by a marked upward trend in production after the first few years. The yield of corn, for example, under the limestone-residues (RL) treatment, has been 36.6 bushels an acre as an average for the 13 crops since full treatment started, but if we take an average of the last five crops the yield rises to 39.5

bushels. Likewise the wheat under this same treatment gives for the 13-year average 16.1 bushels, but for the last five years has given 22.8 bushels.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover grow better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 13.—ALFALFA ON THE OQUAWKA EXPERIMENT FIELD

These pictures show the possibility of improving this unproductive sandy land. Both plots were seeded alike to alfalfa. Where manure alone was applied, the crop was a total failure, but where limestone in addition to manure was applied, nearly 4½ tons of alfalfa hay was obtained as the season's yield.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquis, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1925
33 Saline, 1926
34 Marion, 1926
35 Will, 1926
36 Woodford, 1927
37 Lee, 1927
38 Ogle, 1927
39 Logan, 1927
40 Whiteside, 1928
41 Henry, 1928
42 Morgan, 1929

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 43

DOUGLAS COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER,
AND L. H. SMITH

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URBANA, ILLINOIS, JULY, 1929

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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[1] Engaged in Soils Extension as well as in Soil Experiment Fields.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Douglas county was conducted, and Mr. F. A. Fisher, who, as leader of the field party, was in direct charge of the mapping.

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DOUGLAS COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER and L. H. SMITH[1]

Douglas county is located in the east-central part of Illinois. It lies well toward the southern end of the most recently glaciated area—that of the early Wisconsin. The major portion, 87 percent, of the county is covered with productive, dark-colored prairie soils. The agriculture is typically that of the corn-belt region. Douglas is a relatively small county, having an area of only a little more than 400 square miles.

The climate of Douglas county is typical of central Illinois. It is characterized by a wide range between the extremes of winter and summer and by an abundant, well-distributed rainfall. Since there is no Weather Bureau station in Douglas county, data taken from Urbana in the adjoining county of Champaign are of interest. The greatest range in temperature at Urbana for any one year during the period from 1903 to 1927 was 122 degrees in 1905 and again in 1918. The highest temperature recorded is 103° in 1913; the lowest, 25° below zero in 1905. The average date of the last killing frost in spring is April 26; the earliest in the fall, October 16. The average length of the growing season is 173 days.

The average annual rainfall, as recorded for this 24-year period at Urbana, was 34.50 inches. The average rainfall by months for this period was as follows: January, 2.11 inches; February, 1.82; March, 3.36; April, 3.77; May, 3.80; June, 3.21; July, 2.89; August, 3.57; September, 3.18; October, 2.56; November, 2.13; December, 2.11.

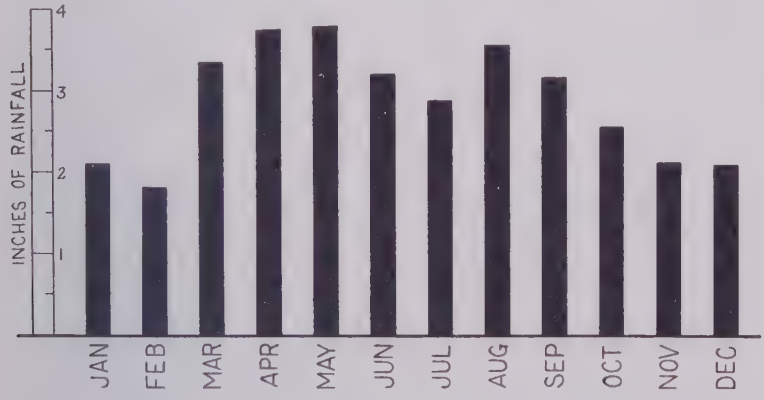


Fig. 1.—The Average Monthly Distribution of Rainfall in Douglas County

It will be noted that the more abundant rainfall occurs mainly during the growing season. This, of course, is favorable to crop production.

[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

AGRICULTURAL PRODUCTION

Douglas county is agricultural in its interests. A very large proportion of the area of the county is suitable for the production of crops. According to the Census of 1925 there were 1,579 farms in the county at that time, which represents a decrease of 446 farms in twenty-five years. About 56 percent of the farms in 1925 were operated by tenants, an increase of about 8 percent in twenty-five years.

The principal crops are those common to the corn belt, as shown by the following figures from the 1925 Census.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn, total acreage	103,038	.....	.....
Harvested for grain	101,116	3,972,565 bu.	39.3 bu.
Cut for silage	300	2,399 tons	7.99 tons
Cut for fodder	145	.....	.....
Hogged-off	1,477	.....	.....
Wheat	21,769	444,508 bu.	20.4 bu.
Oats threshed for grain	38,747	1,564,963 bu.	40.4 bu.
Oats cut and fed unthreshed	85	.....	.....
Timothy	2,109	.....	.....
Timothy and clover mixed	2,386	.....	.....
Clover	6,465	.....	.....
Alfalfa	942	.....	.....
Hay of all kinds, both tame and wild	15,434	20,015 tons	1.30 tons

Broom corn is also an important crop in this county, tho the total area devoted to it is not large, having averaged about 4,300 acres during 1924, 1925, and 1926, with an average yield of 525 pounds to the acre. The acreage of sweet clover in Douglas county has increased from 500 in 1919 to 20,000 in 1927.

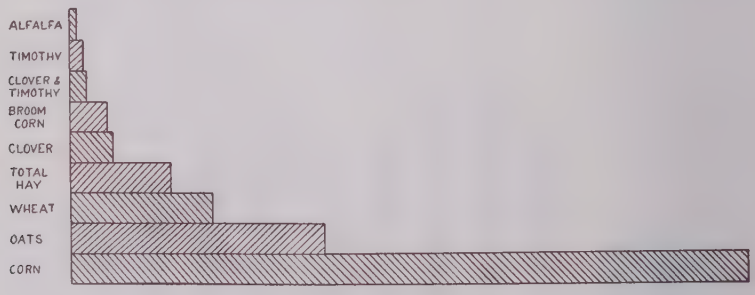


FIG. 2.—RELATIVE ACREAGE OF FIELD CROPS IN DOUGLAS COUNTY

The diagram brings out the preponderance of land devoted to the three grain crops, corn, oats, and wheat. Legume crops might well occupy a larger proportion of the cultivated acreage (data from the 1925 census).

The U. S. Department of Agriculture reports the following average acre-yields for the ten-year period 1916-1925: corn, 35.3 bushels; oats, 32.2 bushels; tame hay, 1.43 tons; winter wheat, 18.9 bushels.

The total value of all livestock and livestock products produced in 1924 was $2,397,316. The following figures, taken from the 1925 Census, show the character of the livestock interests in the county.

NTY

ENT STATION

Animals and Animal Products	*Number*	*Value*
Horses	9,218	$541,656
Mules	1,058	73,844
Cattle (total)	12,597	498,075
Dairy cows	4,237	.....
Dairy products	....	189,186
Sheep	3,412	33,208
Swine	37,631	448,667
Chickens and eggs	....	435,870
Wool	....	7,922

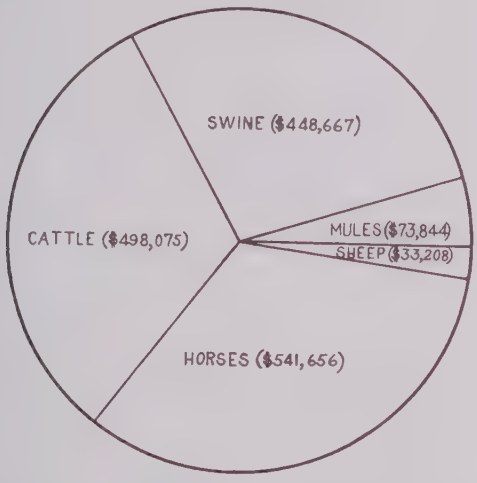


FIG. 3.—RELATIVE VALUE OF THE MORE IMPORTANT CLASSES OF FARM ANIMALS IN DOUGLAS COUNTY

Horses, cattle, and swine are about equal in value.

SOIL FORMATION

GEOLOGICAL ASPECTS

One of the most important periods in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during which and immediately following, the material that later formed the mineral portion of the soils was being deposited. During the Glacial period, great ice sheets moved southward from the centers of accumulation in Labrador, in the Hudson Bay region, and in the northern Rocky mountains. Six great ice movements are generally regarded to have taken place, each of which covered a part of northern United States, altho the same parts were not covered during each advance.

At least two of these great glacial advances designated as the Illinoian and early Wisconsin, covered the area that now constitutes Douglas county. The glacial debris, known as till or drift, deposited by the Illinoian ice sheet, was buried by the debris deposited by the more recent early Wisconsin ice sheet. Altho the Illinoian drift does not enter into the actual composition of the soils of Douglas county, yet the Illinoian glaciation probably had an important effect on the agricultural value of the soils of this county in that it acted as a leveling force, rubbing down the preglacial hills and filling the preglacial valleys.

The soil material of Douglas county is of glacial origin. This material has been reworked by water and wind since the retreat of the last ice sheet. On the higher ridges and steeper slopes erosion has removed the finer soil material nearly as rapidly as it has formed and has deposited much of it on the low-lying, nearly level areas. This action has resulted in youthful soils with little of the horizon development explained below.

PHYSIOGRAPHY AND DRAINAGE

Douglas county is relatively flat except on the morainal ridges in the northeastern and southeastern parts of the county and along narrow belts adjacent to the Embarras and Kaskaskia rivers and their tributaries.

The lower lying portions of the county were swampy until drained by dredge ditches and tile. The swampy condition that prevailed during the period of development of these soils has resulted in the drab and gray color of the lower portions of the profiles. The drainage of the western part of the county is carried by the Kaskaskia river, while that of practically the entire portion of the county east of a north-south line running about a mile west of Arcola is carried by the Embarras river.

The following altitudes indicate the low gradient of the streams in the county. For example, the difference in elevation between Villa Grove and Camargo, both located on the Embarras river, is 10 feet. The distance between these towns is 4½ miles. The following altitudes are given in feet above sea level: Tuscola, 649 feet; Camargo, 637; Newman, 640; Hindsboro, 651; Arcola, 680; Arthur, 658.

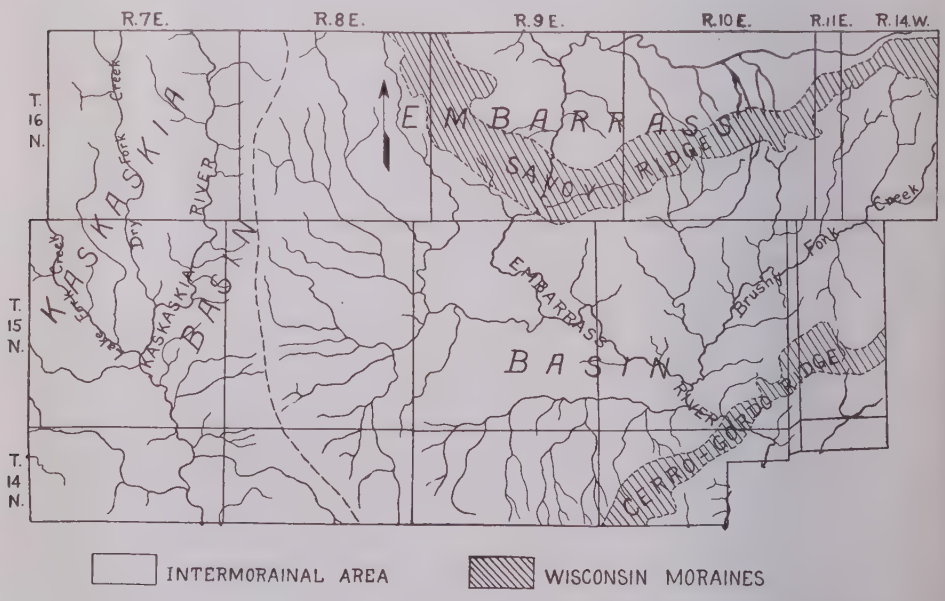
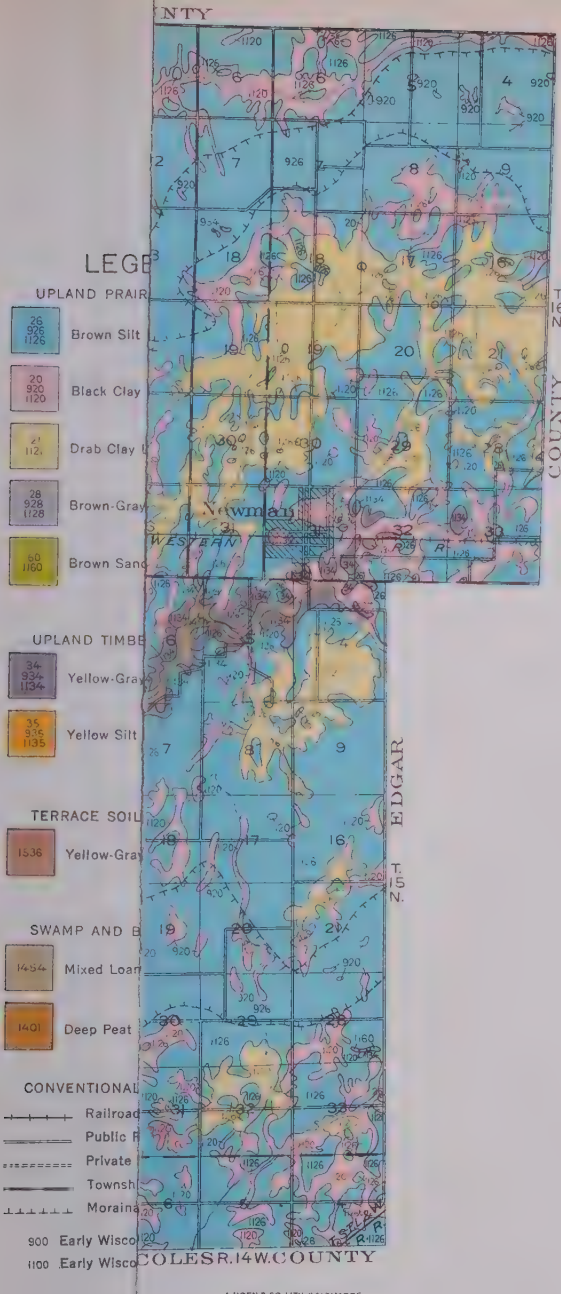


FIG. 4.—DRAINAGE MAP OF DOUGLAS COUNTY SHOWING STREAM COURSES AND OTHER PHYSIOGRAPHIC FEATURES


NTY
LEGE
UPLAND PRAIR
26 926 1126 Brown Silt
20 920 1120 Black Clay
Drab Clay
28 928 1128 Brown-Gray
60 1160 Brown Sand
UPLAND TIMBE
34 934 1134 Yellow-Gray
35 936 1135 Yellow Silt
TERRACE SOIL
1536 Yellow-Gray
SWAMP AND B
1454 Mixed Loam
1401 Deep Peat
CONVENTIONAL
Railroad
Public R
Private
Townsh
Moraina
900 Early Wisco
1100 Early Wisco
Newman
WESTERN
EDGAR
COUNTY
T. 16 N.
T. 15 N.
R.
COLES R. 14 W. COUNTY
A. HOEN & CO. LITH. BALTIMORE

SOIL DEVELOPMENT

During the time which has elapsed since the last ice invasion, weathering and other processes have been active, resulting in the formation of the soils of the county as we know them today.

When first deposited, the general composition of the soil material was rather uniform thruout, but with the passing of time various physical, chemical, and biological agencies of weathering formed soil out of the parent material by some or all of the following processes: the leaching of certain elements, the accumulation of others; the chemical reduction of certain compounds, the oxidation of others; the translocation of the finer soil particles, and the arrangement of them into zones, or "horizons"; the accumulation of organic matter from the growth and decay of vegetable material. One of the very pronounced characteristics observed in most soils is that they are composed of more or less distinct strata, called horizons. As explained somewhat more fully in the Appendix, these horizons are named, from the surface down; *A*, the layer of extraction; *B*, the layer of concentration or accumulation; and *C*, less-altered material, or the layer in which weathering has had less effect. The development of horizons in a soil is an indication of its age.

Since the upland prairie of this region has been occupied, probably continuously, by grass vegetation, relatively large amounts of organic matter have accumulated, resulting in the formation of productive, dark-colored soils. The areas adjacent to streams, which have been occupied by timber, are light-colored because of the relative deficiency of the surface soil in organic matter. The bottom-land soils are made up, for the most part, of alluvial material brought down from the uplands of the immediate vicinity. These soils are relatively young, or immature, and therefore have not developed horizons as have the more mature soils of the upland.

SOIL GROUPS

The soils of Douglas county have been divided into four groups, as follows:

Upland Prairie Soils, dark-colored and usually rich in organic matter, the organic matter having been derived from the decaying roots of the wild prairie grasses which occupied this land for thousands of years.

Upland Timber Soils, those zones along stream courses over which forests grew for a long period of time. These contain in general less organic matter than the prairie soils.

Terrace Soils, including bench lands and second bottoms formed by deposits from flooded streams overloaded with sediment, perhaps at the time of the melting of the glaciers.

Swamp and Bottom-Land Soils, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

Table 1 gives the area of each soil type in Douglas county and its percentage of the total area. It will be observed that 87.24 percent of the county consists of upland prairie, 9.86 percent of upland timber, .01 percent of terrace soils, and 2.89 percent of swamp and bottom-land soils. The accompanying map,

TABLE 1.—SOIL TYPES OF DOUGLAS COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils (900, 1100)			
926, 1126	Brown Silt Loam[1]	231.23	147 987	55.81
920, 1120	Black Clay Loam	69.39	44 409	16.73
1121	Drab Clay Loam	60.49	38 713	14.60
928, 1128	Brown-Gray Silt Loam On Tight Clay	.38	243	.09
1160	Brown Sandy Loam	.05	32	.01
		361.54	231 384	87.24
	Upland Timber Soils (900, 1100)			
934, 1134	Yellow-Gray Silt Loam	39.42	25 228	9.51
935, 1135	Yellow Silt Loam	1.47	940	.35
		40.89	26 168	9.86
	Terrace Soils (1500)			
1536	Yellow-Gray Silt Loam Over Sand or Gravel	.06	38	.01
	Swamp and Bottom-Land Soils (1400)			
1454	Mixed Loam	11.81	7 558	2.85
1401	Deep Peat	.19	121	.04
		12.00	7 679	2.89
	Total area	414.49	265 287	100.00

[1]Including associated types described in the text but not differentiated on the map.

appearing in two sections, shows the location and boundary lines of the various soil types.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix to this report.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN DOUGLAS COUNTY SOILS

Three Depths Represented by Soil Samples

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum, over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.

2. A middle stratum extending from 6⅔ to 20 inches, and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches, and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling we have represented separately three zones for plant feeding. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow, and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore, it is the only stratum which can be greatly changed in composition as a result of adding fertilizing materials.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires to consider the information in that form. In comparing the proportional composition of the different strata, it must be kept in mind that it is based on different quantities of soil, as indicated above. The figures for the middle and lower strata must, therefore, be divided by two and three respectively before being compared with each other or with the figures for the upper stratum.

The data in Tables 2, 3, and 4, showing plant-food content of Douglas county soils, are based in part upon analyses of samples taken from surrounding counties.

Wide Range in Organic Matter and Nitrogen

It can readily be seen from Table 2 that there is a wide variation among the different soil types of Douglas county with respect to their content of the different plant-food elements in the upper 6⅔ inches of soil. The most striking relationship among these variations is observed with respect to organic carbon and nitrogen, the quantities of which run parallel from type to type tho the organic-carbon content is usually 10 to 12 times as great as the nitrogen. The relationship between organic carbon and nitrogen is explained by the well-established fact that all soil organic matter (of which organic carbon is the measure) contains nitrogen and that most of the soil nitrogen—usually 98 percent or more—is present in a state of organic combination, that is, as a part of the organic matter.

The upland prairie soils of Douglas county are, for the most part, relatively high in organic matter and nitrogen, while the upland timber soils are fairly low, there being no overlapping in the two groups with respect to these constituents. This difference is noticeable not only in the surface soil, but extends to the middle and lower strata as well. The smallest amount of both organic matter and nitrogen are found in Yellow Silt Loam. This type is generally subject to surface erosion, which retards the accumulation of organic matter. The bottom-land soils are represented by only two soil types. Only one has been analyzed, the other being too variable to permit sampling. The Deep Peat, as is usually the case, contains a high percentage of organic carbon. However, the type is not so rich in this constituent here as it is in counties further north where the climatic conditions are more conducive to its accumulation.

TABLE 2.—DOUGLAS COUNTY SOILS: PLANT-FOOD ELEMENTS IN UPPER SAMPLING STRATUM, ABOUT 0 TO 6⅔ INCHES[1]

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (900, 1100)							
926, 1126	Brown Silt Loam	54 680	4 650	1 040	770	35 000	8 270	9 810
920, 1120	Black Clay Loam	74 710	7 090	1 830	1 180	32 830	13 600	19 320
928, 1128	Brown-Gray Silt Loam On Tight Clay	38 970	3 510	1 030	780	31 340	5 940	6 500
1160	Brown Sandy Loam	44 070	3 990	1 010	970	26 430	5 9?0	11 560
1121	Drab Clay Loam	53 690	5 240	1 500	950	38 260	12 650	16 520
	Upland Timber Soils (900, 1100)							
934, 1134	Yellow-Gray Silt Loam	25 170	2 220	850	550	34 530	5 740	6 410
935, 1135	Yellow Silt Loam	19 070	1 690	870	380	37 040	9 170	9 760
	Terrace Soils (1500)							
1536	Yellow-Gray Silt Loam Over Sand[2]	.....	.....	.....	.....	.....	.....	.....
	Swamp and Bottom-Land Soils (1400)							
1454	Mixed Loam[3]	.....	.....	.....	.....	.....	.....	.....
1401	Deep Peat[4]	268 560	23 840	1 080	600	11 ?80	1 830	5 770

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]In obtaining the average analyses as presented here samples of some of the types taken in adjacent counties are included. [2]Data not obtained. [3]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type. [4]Amounts reported are for 1 million pounds of Deep Peat.

All of the soils of the county diminish rapidly in their content of both organic matter and nitrogen with increasing depth. This diminution is noticeable even in the second stratum, 6⅔ to 20 inches, and may be observed even in the Deep Peat of this county.

Phosphorus Slightly Lower in Light-Colored Types

The phosphorus content varies somewhat from type to type. It is noticeably lower in the lighter colored, upland timber types, and highest (1,830 pounds) in Black Clay Loam. There is a tendency for the phosphorus content of soils to parallel the organic carbon to some extent, but not closely as does nitrogen. Phosphorus, in contrast with some other elements, is not appreciably removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in plant residues at the expense of underlying strata. Investigations at the Illinois Station have shown that in Brown Silt Loam, for example, about 33 percent of the total phosphorus of the

TABLE 3.—DOUGLAS COUNTY SOILS: PLANT-FOOD ELEMENTS IN MIDDLE SAMPLING STRATUM, ABOUT 6⅔ TO 20 INCHES[1]

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
Upland Prairie Soils (900, 1100)								
926, 1126	Brown Silt Loam	71 110	6 330	1 680	1 140	70 690	19 950	18 220
920, 1120	Black Clay Loam	69 600	6 730	2 670	1 400	68 390	28 140	35 660
928, 1128	Brown-Gray Silt Loam On Tight Clay	33 180	3 570	1 530	980	65 770	15 760	11 840
1160	Brown Sandy Loam	48 810	4 800	1 840	1 380	52 270	21 880	43 710
1121	Drab Clay Loam	60 400	6 220	2 480	1 320	77 450	27 840	30 360
Upland Timber Soils (900, 1100)								
934, 1134	Yellow-Gray Silt Loam	18 640	2 140	1 290	550	71 770	20 350	11 400
935, 1135	Yellow Silt Loam	17 970	2 080	1 790	740	77 990	24 710	11 920
Terrace Soils (1500)								
1536	Yellow-Gray Silt Loam Over Sand[2]	.....	.....	.....	.....	.....	.....	.....
Swamp and Bottom-Land Soils (1400)								
1454	Mixed Loam[3]	.....	.....	.....	.....	.....	.....	.....
1401	Deep Peat[4]	471 280	40 300	2 090	1 520	34 240	4 520	18 900

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]In obtaining the average analyses as presented here samples of some of the types taken in adjacent counties are included. [2]Data not obtained. [3]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type. [4]Amounts reported are for 2 million pounds of Deep Peat.

surface soil is organic, and in Black Clay Loam about 37 percent. It is the second stratum (6⅔ to 20 inches) which furnishes most of the phosphorus thus moved upward. Consequently the phosphorus percentage is higher in the surface soil than in the second stratum, and, except in Yellow Silt Loam, higher than in the lower stratum.

Sulfur Generally Well Supplied

Sulfur, another element used by growing plants, is likewise associated to some degree with organic carbon. This is because a considerable tho varying proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of organic matter. The soils of Douglas county contain from one-half to three-fourths as much sulfur as phosphorus, the amount in the surface soil ranging from 380 to 1,180 pounds per acre. Like phosphorus, the sulfur content generally decreases with increasing depth, partly because some of the sulfur is organic and organic matter decreases with depth, and also in part because organic sulfur is less subject to leaching than calcium sulfate (gypsum), the chief inorganic form of sulfur found in soils. Occasionally very thin strata of nearly pure gypsum are encountered in the lower levels of soils, particularly

TABLE 4.—DOUGLAS COUNTY SOILS: PLANT-FOOD ELEMENTS IN LOWER SAMPLING STRATA, ABOUT 20 TO 40 INCHES[1]

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (900, 1100)							
926 1126	Brown Silt Loam	32 630	3 840	2 190	1 140	108 590	43 070	32 190
920 1120	Black Clay Loam	32 400	3 680	3 210	1 260	104 890	58 790	107 760
928 1128	Brown-Gray Silt Loam On Tight Clay	28 140	3 090	2 270	960	103 580	36 350	29 870
1160	Brown Sandy Loam	25 180	2 720	1 980	1 230	78 120	24 480	28 780
1121	Drab Clay Loam	38 680	4 070	3 020	1 340	113 540	62 060	82 570
	Upland Timber Soils (900, 1100)							
934 1134	Yellow-Gray Silt Loam	17 880	2 450	2 110	880	116 730	42 610	27 520
935 1135	Yellow Silt Loam	17 740	2 580	2 800	960	128 480	40 660	16 400
	Terrace Soils (1500)							
1536	Yellow-Gray Silt Loam Over Sand[2]	.....	.....	.....	.....	.....	.....	.....
	Swamp and Bottom-Land Soils (1400)							
1454	Mixed Loam[3]	.....	.....	.....	.....	.....	.....	.....
1401	Deep Peat[4]	433 020	37 950	2 480	3 990	80 460	7 920	20 400

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]In obtaining the average analyses as presented here samples of some of the types taken in adjacent counties are included. [2]Data not obtained. [3]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type. [4]Amounts reported are for 3 million pounds of Deep Peat.

those high in organic matter, and this may account for the high sulfur content, 3,990 pounds per acre, in the lower stratum of Deep Peat, as found in this county.

The sulfur available to crops is affected not only by the soil supply, but also by that brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption the amount of sulfur thus added to the soil is relatively large. At Urbana during the eight-year period from 1917 to 1924 there was added to the soil by the rainfall an average of 3.5 pounds of sulfur an acre a month. Similar observations have been made in other localities for shorter periods. The precipitation at the various points in the state in a single month has been found to vary from a minimum of ¾ of a pound to more than 10 pounds an acre.

These figures afford some idea of the amounts of sulfur added by rain, and also of the wide variations in amount under different conditions. Considering the amounts which are brought down by rainfall in addition to the soil supply, the facts would indicate that apparently there is little or no need for sulfur fertilizers in Douglas county. In order to determine definitely the response of

crops to applications of sulfur fertilizers, experiments with gypsum have been started on a number of experiment fields in various parts of Illinois.

Potassium Content Lower in the Sandy and Peat Soils

The potassium content of the various soil types also exhibits wide variation. Brown Sandy Loam, the only type of a sandy character in the county, is noticeably lower in potassium than the other types thruout the entire depth sampled. Sandy soils carry a large proportion of their potassium in the sand grains. The relatively smaller total surface exposed in the case of these coarser soil particles greatly lowers the rate at which potassium is dissolved, and hence its availability. The deficiency of available potassium in the sandy soils is partly, but not wholly, offset by the greater facility with which the roots of crop plants can ramify in these soils as compared with the heavier types. The potassium concentration in the mineral soils shows very little variation at the different depths.

So far as chemical composition is concerned, Deep Peat as found in Douglas county is not representative of this type as it generally occurs in the state. The comparatively low organic-matter content (for the type) with the accompanying larger proportion of mineral matter, is reflected in the potassium figure, 11,380 pounds, an amount that is two to three times as high as the usual quantity for this type.

Wide Variations in Calcium and Magnesium

Soils, in general, exhibit wide variations in the content of calcium and magnesium, and Douglas county presents no exception to this rule. In the surface soil magnesium varies from 1,830 pounds per acre in Deep Peat to 13,600 pounds in Black Clay Loam, while calcium varies from 5,770 pounds to more than 19,000 pounds. The presence of calcium in amounts of this magnitude is no indication that the soil may not need lime. In acid soils fairly large amounts of calcium may be found. It is locked up, however, by combination in silicate minerals, and thus while serving to reduce acidity, it may become available so slowly in some cases as to make the lack of calcium as a plant-food element a limiting factor in crop growth. The application of lime or limestone supplies readily available calcium and at the same time serves to correct soil acidity.

Some of the variations in total calcium appear to be erratic, particularly in the lower stratum, where very high values are observed in Black Clay Loam, Drab Clay Loam, and Deep Peat. In these types some of the soils contain calcium carbonate (limestone) within the depth sampled, which condition accounts for the high total calcium. Calcium carbonate is readily soluble in soil water, and under natural conditions the surface soil loses its calcium carbonate first by leaching, followed by removal to greater and greater depths. Thus in no case do we find calcium carbonate in the surface soil in Douglas county, even tho an acid surface may be underlain by free calcium carbonate at a greater or less depth.

Some increase in total magnesium ordinarily accompanies the high calcium of the carbonate-containing soils. The increases are not great, however, because

of the inability of magnesium carbonate to exist long in the soil in that state. The carbonate of carbonate-containing soils is chiefly calcium carbonate.

In the non-carbonate, upland soils, variations in the amounts of calcium and magnesium at the different depths give some indication of the movement of these elements in soil formation. In the surface soil the calcium usually exceeds the magnesium in amount, as a result of the preponderance of calcium in the soil-forming materials. As we pass into the lower strata we find the magnesium content increasing and gaining on the calcium, even exceeding it in some cases.

These facts aid in explaining what has been going on in the process of soil development with respect to these two elements. As they are dissolved and carried downward in solution, magnesium, owing to its chemical nature, is more readily reabsorbed and held by the soil mass than is calcium. Thus calcium is gradually replaced by magnesium, being forced into solution and carried farther down. Consequently, while magnesium accumulation begins in the middle stratum and increases with depth, the liberated calcium is carried down into or below the third sampling stratum before it is reabsorbed, or it may be washed away entirely in the drainage water. The extent of the translocation of these two elements as revealed by the analyses aids to some extent in estimating the relative degree of maturity of the different types. The increasing proportion of magnesium to calcium in the lower levels becomes more pronounced with increasing maturity of the soil. Thus we see a correlation between this chemical soil characteristic and the processes of soil development.

Local Tests for Soil Acidity Often Required

It is impracticable to attempt to obtain an average quantitative measure of the calcium-carbonate content or of the acidity of a given soil type because, while some samples will contain large amounts of calcium carbonate, others may contain none, but on the other hand may actually have a lime requirement due to the soil acidity. We thus have what may be considered positive and negative values ranging, perhaps widely, on the opposite sides of the zero or neutral point, the numerical average of which could have no significance whatever, since such an average would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types.

The qualitative field tests made in the process of the soil survey are much more numerous than the chemical analyses made in the laboratory, and do give a general idea of the predominating condition in the various types as to acidity or alkalinity. These tests, therefore, furnish the basis for some general recommendations which are given in the descriptions of individual types on pages 14 to 19. To have a sound basis for the application of limestone the owner or operator of a farm must often determine individually the lime requirements of his different fields. The section in the Appendix dealing with the application of limestone (page 28) is pertinent and should be read in this connection.

Supplies of Different Elements Not Proportional to Crop Removal

In the foregoing discussion we have considered mainly the amounts of the plant-food elements in the surface 6⅔ inches of soil, and rather briefly the relative amounts in the two lower strata. We have noted that some of the elements of plant food exhibit no consistent change in amount with increasing depth. Other elements show more or less marked variation at the different levels, the trend of these variations serving in some cases as clues to the relative maturity of different soil types and the processes involved in their development.

By adding together the corresponding figures for all three strata, we have an approximate invoice of the total plant-food elements within the feeding range of most of our field crops, since the major portion of their feeding range is included in the upper 40 inches of the soil. One of the most striking facts brought out by this consideration of the data is the great variation within a given soil type in the relative abundance of the various elements present as compared with the amounts removed by crops. For example, in one of the important types in Douglas county, Brown Silt Loam, Upland, we find that the total quantity of nitrogen in all three strata is 14,820 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus is approximately one-third as much, or 4,910 pounds, but this amount is equivalent to the phosphorus in about twice as much corn, namely, 28,800 bushels. In the surface stratum, however, which is the zone of most intensive crop feeding, we find the relative amounts of nitrogen and phosphorus more nearly in accord with the rate of removal of these elements by crops. Here the nitrogen is equivalent to 4,650 bushels of corn, and the phosphorus to 6,000 bushels, or only one-third more than the nitrogen equivalent.

Other types show marked contrast to Brown Silt Loam, just discussed, with respect to total soil content in relation to rate of removal by crops. However, in most soils, except those which are peaty, phosphorus is more abundant than nitrogen when considered in terms of crop equivalents rather than in actual pounds per acre of the respective elements.

Service and Limitations of Chemical Investigations in Soil Improvement

The foregoing discussion should not be taken to mean that it is possible to predict how long any certain soil could be cropped under a given system before it would become exhausted. Nor do the figures alone indicate the immediate procedure to be followed in the improvement of a soil. It must be kept in mind that the *amount* of plant food shown to be present is not the sole measure of the ability of a soil to produce crops. The *rate* at which these elements are liberated from insoluble forms and converted to forms that can be used by growing plants is a matter of at least equal importance, as explained on page 26, and is not necessarily proportional to the total stocks present. One must know, therefore, how to cope with the peculiarities of a given soil type, if he is to secure the full benefit from its stores of the plant-food elements. In addition, there are always economic factors that must be taken into consideration, since it is necessary for one to decide at how high a level of productive capacity he can best afford to maintain his soil.

The chemical investigations carried out in connection with the soil survey, of which the analyses here reported are a part, are of value chiefly in two ways. In the first place, they reveal at once outstanding deficiencies or other chemical characteristics which alone would affect soil productivity to a marked extent, or point the way to corrective measures. It should be borne in mind, however, that fairly wide departures from the usual are necessary before the chemical analysis alone can be followed as a guide in practice without supplementary information from other sources. It is probable that the results of chemical soil analyses are frequently misused by attempting to interpret small differences in the amount of a certain plant-food element as indicative of corresponding differences in the fertilizer need. For example, differences of only 100 or 200 pounds of phosphorus per acre in soils containing 1,000 pounds or thereabout in the surface soil should not be considered as of any agricultural significance. Again, 100 pounds to the acre of active nitrogen added by plowing down a clover crop may be of more importance to the succeeding crop than a difference in soil composition of 1,000 pounds an acre of nitrogen as shown by the analysis. An example of the direct use of the results of chemical investigations is the marked shortage of potassium in peat soils associated with the need for potassium fertilizers; another case is the determination of the lime need of soils by chemical tests.

The second use of chemical methods is in the more detailed study of soils. The processes of soil development leave their imprint upon the soil both in its physical conformation and also in its chemical characteristics. Likewise every operation in the handling of the soil and every application of fertilizer or liming material disturbs its equilibrium, setting up new reactions, which are in turn reflected in crop adaptability, producing capacity, and agricultural usefulness. Chemistry is a most important tool in tracing and characterizing such changes, and chemical investigations are undertaken with the aim of aiding in the classification of soils and making possible more accurate prediction of their agricultural value and fertility needs, as well as response to different methods of management.

DESCRIPTION OF SOIL TYPES

The soil survey of Douglas county, upon which this report is based, was made in 1914. In the meantime there has been a gradual accumulation of new soil facts. As knowledge regarding soils accumulated, additional soil types were recognized. At the present time several types shown on the soil map of Douglas county are each considered to include two or more types. For the purposes of this Report, these types, which are now differentiated but not shown on the map, will be described so that they may, to some extent at least, be recognized in the field.

UPLAND PRAIRIE SOILS

The upland prairie soils of Douglas county occupy 361.54 square miles, or 87.24 percent of the area of the county. The dark color of the prairie soils is due to an accumulation of organic matter from the fibrous roots of the prairie

grasses that grew on this land for centuries. A covering of fine soil and a mat of vegetative material by partially excluding the oxygen protected these roots from rapid and complete decay. From time to time the mat of old grass stems and leaves was partially destroyed by prairie fires and decay, but it was constantly being renewed, and while it added but little organic matter to the soil directly, it served to retard the decay. From a sample of virgin bluestem sod, one of the most common prairie grasses, it has been determined that an acre of this soil to a depth of 7 inches may contain as high as 13½ tons of roots.

Brown Silt Loam (926, 1126)

Brown Silt Loam, as mapped in this county, is now recognized to include at least four, and probably five soil types. Four of these will be described. The fifth occurs in portions of Piatt, Macon, Moultrie, and Coles counties, but has not as yet been studied sufficiently to justify considering it an established type. The four types now recognized are Brown Silt Loam On Clay, Brown Silt Loam, Brown Silt Loam On Drift, and Light Brown Silt Loam On Drift. These types all occur on the areas shown on the map as Brown Silt Loam. Their occurrence bears a rather definite relation to topography, as will appear from the descriptions which follow.

Brown Silt Loam On Clay. This type occurs on nearly level areas. It was formed under conditions of intermittently poor drainage which resulted in an accumulation of considerable fine-textured material in the subsoil. Associated with this fine texture and plasticity of the subsoil, or *B* horizon, is a gray color showing a lack of free air movement. The surface soil, or A_1 horizon, is dark brown in color and is in some cases rather heavy for a silt loam. The subsurface, or A_2 horizon, is heavier than the A_1 and lighter in color.

Management. This type, even tho it has a heavy subsoil, will underdrain satisfactorily. In draining, the strings of tile should be placed closer together than for any of the other types mapped as Brown Silt Loam. After good drainage is secured, regular additions of fresh organic matter should be provided, for otherwise this soil will gradually become more difficult to work. Limestone is needed for sweet clover or alfalfa, tho in light applications. The lowest portions of the type may need no limestone and occasionally small alkali spots occur. The harmful effects of the alkali may be corrected by applying 75 to 100 pounds of potash for corn. This type is similar to the soil on the Hartsburg and Aledo experiment fields. The results from these two fields are in agreement in indicating the value of manure on all the crops of the rotation; the value of residues, particularly for corn; the relatively small returns from limestone used in addition to manure and residues; and the failure of rock phosphate as used on these fields, particularly in the manure system, to cause sufficient increase in yields to justify advising its indiscriminate use on this soil type. If alfalfa is to be seeded, the application of 1,000 pounds of rock phosphate, or 500 pounds of superphosphate an acre would be advisable; or, if sweet clover is to be seeded in wheat, it would be advisable to make a trial application of either of these materials after plowing but before working down the wheat seed bed. The reader is referred to page 31 for a further discussion of the phosphate problem.

Brown Silt Loam. This type occurs on undulating topography. It has good surface drainage and underdrainage and the profile is friable and easily permeable to roots as well as to water. A heavier application of limestone is needed than on the preceding type and it is more uniformly acid, tho it is not strongly acid. The surface soil, or A_1 horizon, is brown in color and unlike the preceding type, does not tend to be too heavy to classify as a true silt loam. The subsurface, or A_2 horizon, is distinctly yellowish and is not much heavier than the A_1. The subsoil, or B horizon, is brownish yellow with some gray mottling present; it is a clay loam but is friable and only medium plastic.

Management.—This type is similar to the soil on the Kewanee experiment field. The results from this field (page 46) show a good response to manure alone and to residues and lime in combination. Where lime was used in addition to manure, an additional increase in yield was secured, but the increase was not so large as where lime was used in addition to residues. This behavior indicates that manure satisfies in part the same deficiency that lime satisfies on this medium-acid soil. The same is true in regard to the use of rock phosphate. In combination with stable manure and limestone the increases in crop yields have been too small to pay the cost of the phosphate. Where green manures and residues were the source of nitrogen and organic matter, however, rock phosphate has been used with increasing benefit which in later years has been sufficient to yield a good profit. The Bloomington experiment field is located in part on this same type of soil. The results from this field (page 48), on which various phosphate carriers have been used, show excellent returns for phosphorus and lead to the recommendation that some form of phosphate be given a trial. The reader is referred to the discussion of phosphatic materials on page 31.

Brown Silt Loam On Drift. This type occurs on rolling topography and is found in the southeastern and northeastern portions of the county. In color the entire profile of Brown Silt Loam On Drift is similar to Brown Silt Loam described above, but it differs from the latter in character of the soil material in the lower horizons, particularly in having much more sand and gravel and in being more compact. The surface soil, or A_1 horizon, to a depth of about 8 inches is brown in color and a silt loam in texture. It frequently contains a limited number of chert and other rock fragments. The A_2 horizon is a yellowish brown silt loam containing some rock fragments and extends to a depth of about 18 or 20 inches. The B horizon is a medium-mottled, dark yellow, sandy and gravelly clay, medium compact and slightly plastic. The C horizon is a yellow, sandy, gravelly clay loam, fairly friable, and not much compacted.

Management.—Brown Silt Loam On Drift is thought to be very similar in management requirements to Brown Silt Loam, the last type described. It differs in being slightly more acid, somewhat lower in organic matter, and more subject to erosion.

Light Brown Silt Loam On Drift. This type differs from Brown Silt Loam On Drift in being much lower in organic matter, more acid, and more subject to serious erosion. It is all tillable, but is spoken of by farmers as being a "thin" soil. This type occurs only on the more pronounced slopes of the two morainal

ridges shown on the soil map. The surface, or A_1 horizon, is light brown or reddish brown in color and in places contains considerable glacial gravel. The subsurface, or A_2 horizon, is yellowish brown in color and contains more gravel than the surface. The subsoil, or B horizon, is gravelly glacial drift, somewhat compact but not plastic. The thickness of the various horizons varies because of differences in the rate of erosion on different areas. Carbonates commonly occur at a depth of 40 to 50 inches.

Management.—This type is less productive than any of those previously described. It needs frequent additions of fresh leguminous organic matter. It is more acid than less rolling land. It must be handled carefully if erosion is to be reduced below the point where it is very harmful. The trial of either rock phosphate or superphosphate for wheat which is to be seeded to clover is advised on this soil.

Black Clay Loam (920, 1120)

Black Clay Loam, as mapped in Douglas county, is now recognized to include four types. These four types will not be described as they do not differ in topography so strikingly as do the separations noted for Brown Silt Loam and are therefore less easily recognized. Therefore instead of attempting to describe each type as now differentiated, the following generalized description is given.

The A_1 horizon is 10 to 12 inches deep, and is a dark brown to black clay loam. The A_2 horizon usually extends to a depth of about 20 inches, is drabbish black in color, and is somewhat heavier than the A_1 horizon. It usually contains small yellow spots and in the lighter portions of the type is distinctly yellow instead of drabbish black. The B horizon in the heavier portions of the type is a gray or heavily mottled, compact, plastic clay; in the lighter portions it is a strongly mottled yellow, compact, medium-plastic clay or clay loam.

Management.—It should be noted that alkali spots occur in Black Clay Loam and that potash treatment is needed on some of them because of the high concentration of soluble salts. Lime is generally not needed on this soil but regular additions of fresh organic matter should be provided as an aid in maintaining a good physical condition. According to the results from the Minonk and Hartsburg experiment fields, the use of phosphate is not likely to prove profitable on this soil. However, if no manure is available it might be well to try rock phosphate at the rate of about 1,000 pounds an acre or superphosphate at the rate of about 250 pounds an acre for wheat. The summarized results from the Minonk and Hartsburg fields are given on pages 52 and 53.

Drab Clay Loam (1121)

Drab Clay Loam is clearly a soil formed under conditions of poor drainage. The reason for its drab color instead of black is not apparent, tho it seems to be associated with a set of conditions which limited the growth of the native grasses.

The surface, or A_1 horizon, is about 7 inches thick and is usually a drabbish black clay loam or silty clay loam. The subsurface, or A_2 horizon, is somewhat lighter in color than the surface, usually being drabbish brown. The sub-

soil, or *B* horizon, is drab or yellowish drab containing reddish brown spots. It is heavy but will underdrain.

Management.—Drab Clay Loam is usually not acid and in places is alkaline. It is relatively low in organic matter. It requires thoro underdrainage. Much has been done by the construction of dredge ditches and laying of tile to take care of the excess water on this soil. Alkali spots are common and lime concretions and marly material are often found within forty inches of the surface.

Brown-Gray Silt Loam On Tight Clay (928, 1128)

Brown-Gray Silt Loam On Tight Clay is of little importance in Douglas county because of its small extent, occupying a total of less than half a square mile. The areas southeast of Hindsboro are typical of this kind of soil, having a grayish brown surface, gray subsurface, and mottled gray, impervious subsoil. Further information regarding this soil type may be had by correspondence with the Experiment Station.

UPLAND TIMBER SOILS

The upland timber soils are not extensively developed in Douglas county. They cover altogether only about 40 square miles, or a little more than 9 percent of the area of the county. They occur adjacent to the streams.

These soils are usually characterized by a yellow or yellowish gray color which indicates a low organic-matter content, resulting from the long-continued growth of forest trees. As the forests invaded the prairies, the following effects were produced: the shading by the trees prevented the growth of grasses, the roots of which are mainly responsible for the large amount of organic matter in the prairie soils; and the trees themselves added little organic matter to the soil, for the leaves and branches either decayed or were destroyed by forest fires.

The timbered soils are of two kinds, the undulating and the eroded.

Yellow-Gray Silt Loam (934, 1134)

Yellow-Gray Silt Loam as mapped in Douglas county, includes several light-colored soil types. The flat, nearly level areas have a relatively impervious, gray subsoil, while the better drained areas show little accumulation in the subsoil and the color is reddish or yellowish. On the rolling area in the southeastern part of the county, the gravelly drift is near the surface. No attempt will be made here to describe this type in further detail since the variations are so great that a sufficiently broad description would have no meaning.

Management.—The nearly level portions of this type are more acid than the undulating and rolling portions and are naturally poorly drained. Lime is a general requirement, tho the amount needed varies as above indicated and also with other factors, as for example, with the length of time and the intensity with which a field has been farmed. Leguminous organic matter is also a general requirement and everywhere on this type where the land is farmed provision should be made for the regular growth of clover, preferably sweet clover. Phosphate should give profitable returns on the undulating portions of this

type, particularly if used for wheat. Either rock phosphate or superphosphate may be tried, the former at the rate of about 1,000 pounds an acre and the latter at the rate of about 250 pounds.

Yellow Silt Loam (935, 1135)

The occurrence of Yellow Silt Loam in Douglas county is limited almost entirely to the southeastern part of the county. It is of little importance because of its limited extent. The slopes are, for the most part, short and steep and suited only to timber or pasture. The character of this soil depends on the nature of its parent material and the amount of erosion which has taken place. Practically no profile development has taken place.

TERRACE SOILS

Relatively small areas of terrace soil occur in Douglas county. The terraces were built up, for the most part, during and immediately following the Glacial period when overloaded and flooded streams deposited an immense amount of material in their channels. Later, as the streams diminished in size or cut their channels deeper, new bottoms were formed leaving the old flood plains above overflow. It was upon these plains that the terrace soils developed.

Yellow-Gray Silt Loam Over Sand or Gravel (1536)

Yellow-Gray Silt Loam Over Sand or Gravel is of little importance in Douglas county because of its limited extent. It is similar to the flat Yellow-Gray Silt Loam, Upland. The underlying sand or gravel is sufficiently deep that it does not cause a drouthy condition, and yet its presence improves the underdrainage. Limestone should be supplied and clover grown as is suggested for Yellow-Gray Silt Loam, Upland, described on the preceding page.

SWAMP AND BOTTOM-LAND SOILS

Swamp and bottom-land soils include the flood plains along the rivers and creeks and the small areas of Peat south and east of Hindsboro.

Mixed Loam (1454)

The name Mixed Loam is given to those narrow tracts of land found in the stream valleys and made up of such a mixture of different kinds of soil as to render impossible any definite type description.

Management.—The diversity of Mixed Loam calls for different tillage methods where the extremes in the type occur. Some areas are so heavy as to require care in working them at the right moisture content, while others are very sandy. The type in general is not acid and needs only fresh organic matter and intelligent tillage. It is a productive soil but is so generally subject to overflow that much of it is used for timber or pasture. It is excellent corn land except where overflow is too frequent.

Deep Peat (1401)

Deep Peat occurs only in three small areas south and east of Hindsboro. Information will be furnished by correspondence regarding these areas.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items, such as native vegetation (whether timber or prairie), topography, and geological origin and formation, may assist in the differentiation of types, altho they are not fundamental to it.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a matured soil, three horizons designated as *A*, *B*, and *C* are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the *A* horizon.

C designates the layer lying below the *B* horizon and in which the material has been less affected by the weathering processes.

Frequently differences within a stratum or zone are discernible, in which case it is subdivided and described under such designations as A_1 and A_2, B_1 and B_2, etc.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in differentiating soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made wherever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of this report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their respective index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoian moraines,* including the moraines of the Illinoian glaciations
300 *Lower Illinoian glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoian glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoian glaciation,* covering about fourteen counties northwest of the middle Illinoian glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoian
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation

1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* formed by material derived from the Illinoian or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the remainder of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoian glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to the last of November. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction.

FIG. 5.—EXAMINING THE SOIL PROFILE

Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development in road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil

management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

At least ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed

FIG. 6.—ALL ESSENTIAL PLANT-FOOD ELEMENTS MUST BE PRESENT

The jars in which these corn plants are growing contain pure sand to which have been added various combinations of the essential plant-food elements. If a single one of these elements is omitted, the plants cannot develop; they die after the small supply stored in the seed becomes exhausted.

from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants are dependent upon the soil for the other elements, and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5.
[2]Young second-year growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering

bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4_1 have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

The nitrogen problem is one of foremost importance in American agriculture. There are four reasons for this: nitrogen is becoming increasingly deficient in most soils; its cost when purchased on the open market is often prohibitive; it is removed from the soil in large amounts by crops; and it is readily lost from soils by leaching. A 50-bushel crop of corn requires about 75 pounds of nitrogen for its growth; and the loss of nitrogen from soils by leaching may vary from a few pounds to over one hundred pounds an acre in a year, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about 69 million pounds of atmospheric nitrogen. Leguminous plants such as clover are able, with the aid of certain bacteria, to draw upon the inexhaustible supply of air nitrogen, utilizing it in their food requirements. In so doing these leguminous plants, thru the decay of their own

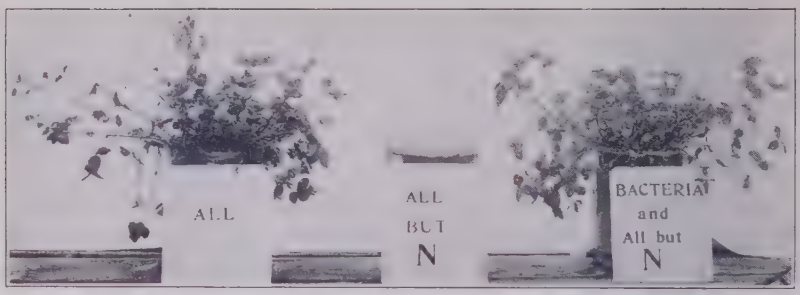


FIG. 7.—LEGUMES CAN OBTAIN THEIR NITROGEN FROM THE AIR

The photograph tells the story of how clover benefits the soil. In the pot at the left all the essential plant-food elements, including nitrogen, are supplied. In the middle jar all the elements, with the single exception of nitrogen, are present. At the right nitrogen is likewise withheld but the proper bacteria are supplied which enable the clover to secure nitrogen from the air.

tissues, add to the soil nitrogen that has been taken from the air and transformed into food material that can be assimilated by other kinds of crops that follow.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

Different soil types display great variation in phosphorus content. In Illinois soils a range from 320 to 4,900 pounds an acre has been found in the surface 6⅔ inches, depending mainly on the origin of the soil.

The removal of phosphorus by continuous cropping slowly reduces the amount of this element available for crop use unless its addition is provided for by natural means such as overflow, or by agricultural practices such as the addition of phosphatic fertilizers and the use of rotations in which deep-rooting leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different phosphorus-containing materials that are used as fertilizers. The more important of these are rock phosphate, superphosphate, bone meal, and basic slag.

Rock Phosphate.—Rock phosphate is a mineral substance found in vast deposits in certain regions. A good grade of the rock should contain 12 to 15 percent of the phosphorus element. The rock should be ground to a powder fine enough to pass thru a 100-mesh sieve, or even finer.

Superphosphate.—Superphosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. By further processing, different concentrations are produced. The most common grades of superphosphate now on the market contain respectively 7, 8¾, and 10½ percent of the element phosphorus, and even more highly concentrated products containing as high as 21 percent are to be had. In fertilizer literature the term phosphorus is usually expressed as "phosphoric acid" (P_2O_5) rather than the element phosphorus (P), and the chemical relation between the two is such as to make the above figures correspond to 16, 20, 24, and 48 percent of phosphoric acid respectively. Besides phosphorus, superphosphate also contains sulfur, which is likewise an element of plant food. In general, phosphorus in superphosphate is considered to be more readily available for absorption by plants than that of raw rock phosphate.

Bone Meal.—Prepared from the bones of animals, bone meal appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen. If the material is purchased only for the sake of the phosphorus, the cost of the nitrogen represents a useless expense. Steamed bone meal is prepared by extracting most

of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate, containing about 10 to 12 percent of the element phosphorus and about 1 percent of the element nitrogen.

Basic Slag.—Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore tends to influence the soil reaction in the direction of reducing soil acidity.

Comparative Value of Different Forms of Phosphorus.—Obviously the carrier of phosphorus that gives the most economical returns, considered from all standpoints, is the best one to use. Altho this matter has been the subject of much discussion and investigation, the question remains unsettled. The fact probably is that there is no single carrier that will prove the most economical under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

The relative cheapness of raw rock phosphate as compared with the treated material, superphosphate, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in the form of rock than in the form of superphosphate, the ratio being, under present market conditions, roughly speaking 3½ to 1; that is to say, a dollar will purchase about three and a half times as much of the phosphorus element in the form of rock phosphate as in the form of superphosphate, and this is an important consideration if one is interested in building up a phosphorus reserve in the soil.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using superphosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, the silt loams and clay loams, are well stocked with potassium, altho it exists mainly in a very slowly soluble form. Many field experiments in various sections of Illinois during the past twenty-five years have shown little or no response to the application of potassium in the production of our common grain and hay crops. On the light-colored soils of southern Illinois, however, where stable manure has not been employed, potassium has been applied with profit, the benefit appearing mainly in the corn crop.

Peat soils are usually low in potassium content. It has frequently been demonstrated in field experiments located on peat land that the difference between success and failure in raising crops depends upon the application of a potash fertilizer.

Potassium has proved beneficial also on the so-called "alkali" spots occurring on certain soil types that are rather high in organic matter, including peat and very dark-colored sandy, silt, and clay loams. The potassium salts in this case appear to exert a corrective influence over what seems to be an unbalanced plant-food condition caused by an excess of nitrate in the soil.

Potassium fertilizer may be procured in the form of one of its salts, such as chlorid, sulfate, or carbonate of potassium, and any of these materials may be applied, where needed, at the rate of 50 to 150 pounds an acre, according to the method of distribution. For our most common crops about the only basis for choosing among these forms is the matter of price, taking into consideration the potassium content. Kainit is another substance containing potassium, but it is combined with magnesium in the form of a double salt. It is therefore less concentrated than the salts mentioned, and so should be applied in larger quantities. An application of about 200 pounds or more of kainit to the acre is suggested.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The

practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the corn is planted. Whether the crop be corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the best adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)
Sixth year —Clover, or clover and grass

In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed; or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

The two following rotations are suggested as especially adapted for combating the corn borer:

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Corn (for silage)
Sixth year —Wheat (with sweet clover)

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Wheat (with alfalfa)
Sixth year —Alfalfa

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)
Fifth year —Clover

First year —Corn
Second year —Soybeans
Third year —Corn
Fourth year —Wheat (with legume)
Fifth year —Legume

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field rotating over all fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute barley or rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover, or it may include alfalfa used as a biennial. The mixing of alfalfa with clover seed for a legume crop is a recommendable practice. In connection with livestock production it may be desirable to mix grass with the clover for pasture or hay. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to Those Occurring in Douglas County)

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various soil types. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on soil types described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to forty acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with each crop represented every year.

Farming Systems

On most of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system but certain modifications have been introduced in recent years, as explained in the descriptions of the respective fields.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots at the beginning was usually standardized according to a rather definite system. With advancing experience, however, new problems arose calling for new experiments, so that on most of the fields plots have been divided and a portion given over to new systems of treatment, at the same time maintaining the original system essentially unchanged from the beginning.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—Limestone has usually been applied at the rate of 4 tons an acre as an initial application, and 2 tons an acre every four years thereafter until a considerable excess has accumulated in the soil. Rock phosphate has been applied at the rate of one ton an acre at the beginning, followed by an annual acre-rate of 500 pounds applied once in the rotation until a considerable excess has accumulated. Potassium has been applied usually in the form of 200 pounds of kainit a year. When kainit was not available, owing to conditions brought on by the World War, potassium carbonate was used.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated, (sP = superphosphate, bP = bone meal, rP = rock phosphate, slP = slag phosphate)
K = Potassium (usually in the form of kainit)
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed

THE ALEDO FIELD

An experiment field representing the soil type Brown Silt Loam on Clay is located in Mercer county just west of Aledo. This field has been in operation since 1910. From its physical aspects this field should be well adapted to experimental work, the land being unusually uniform in topography and in soil profile.

There are two general systems of plots and they are designated as the major and the minor systems. The major system comprizes four series made up of 10 plots each. The plots were handled substantially as described

for standard treatment until 1918, when it was planned to harvest the first crop of red clover on the residues plots for hay and to plow down the second crop if no seed were formed. In 1921 the return of the oat straw was discontinued. In 1923 the rotation was changed to one of corn, corn, oats and wheat. In this rotation it was planned to seed hubam clover in the oats on all plots, for use as hay or for soil improvement, and common sweet clover in the wheat on the residues plots for use as a green manure. Since this change, no residues except cornstalks and the green manure have been returned to the residues plots. The limestone applications were temporarily abandoned in 1923 after the different series had received 7½ to 9 tons an acre and no more will be applied until a need for lime appears. The phosphate applications were evened up to a total of 4 tons an acre in 1924, and no more will be applied for some time at least.

A summary of the results, showing the average annual yields obtained for the period beginning when complete soil treatment came into sway is given in Table 7. Comparisons in terms of crop increases, intended to indicate the effect of the different fertilizing materials applied is shown in the lower section of the table.

In looking over these results, one may observe first the beneficial effect of animal manure on all crops but especially on corn. This suggests the advisa-

TABLE 7.—ALEDO FIELD: SUMMARY OF CROP YIELDS

Average Annual Crop Yields 1912-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Corn	Oats	Clover	Soy-beans[1]	Stubble Clover	
							Sweet clover	Hubam[2]
		14 crops	*23 crops*	*16 crops*	*6 crops*	*3 crops*	*2 crops*	*2 crops*
1	0	29.9	56.0	58.6	(2.21)	(1.60)	.....	.....
2	M	35.1	69.9	65.7	(2.74)	(1.63)	.....	.....
3	ML	35.5	73.5	68.5	(3.12)	(1.60)	.....	(1.12)
4	MLP	37.2	74.7	69.5	(3.05)	(1.61)	.....	(1.20)
5	0	31.0	58.0	60.0	(2.00)	(1.61)	.....	.....
6	R	31.8	64.5	61.5	(1.91)	(1.65)	.....	.....
7	RL	34.2	71.7	66.8	(1.79)	(1.88)	(1.57)	(.52)
8	RLP	37.9	74.1	68.3	(2.08)	(2.03)	(1.66)	(.80)
9	RLPK	37.8	75.4	70.7	(1.73)	(2.09)	(1.99)	(.57)
10	0	30.2	56.3	58.8	(2.38)	(1.62)	.....	.....
	Crop Increases							
	M over 0	5.2	13.9	7.1	(.53)	(.03)	.....	.....
	R over 0	.8	6.5	1.5	−(.09)	(.04)	.....	.....
	ML over M	.4	3.6	2.8	(.38)	−(.03)	.....	(1.12)
	RL over R	2.4	7.2	5.3	−(.12)	(.23)	(1.57)	(.52)
	MLP over ML	1.7	1.2	1.0	−(.07)	(.01)	.....	(.08)
	RLP over RL	3.7	2.4	1.5	(.29)	(.15)	(.09)	(.28)
	RLPK over RLP	− .1	1.3	2.4	−(.35)	(.06)	(.33)	−(.23)

[1]Soybeans all evaluated as hay, altho some plots were harvested as seed.
[2]Two crops hubam on Plots 3 and 4 but only 1 crop on 7, 8, and 9.

bility of carefully conserving and regularly applying all stable manure. Residues alone have been beneficial for the second year corn but have shown little effect on the other crops of the rotation.

Where limestone has been applied, there is usually some increase in average yields, sufficient, at least, to cover the cost of the limestone.

The addition of rock phosphate to the treatment has had very little effect in the manure system. Somewhat more favorable are the results in the residues system, but under present market conditions, the cost of rock phosphate applied in the manner of these experiments exceeds the value of the crop increase. However, the economic story has not all been told, for the application of lime and phosphate has been discontinued in order to observe the residual effects. The results of the next few years, therefore, will be awaited with great interest.

For the effect of potassium treatment Plots 8 and 9 should be compared. No significant response appears from this treatment so far as these common field crops show.

Special Phosphate Experiments

The so-called minor system of plots on the Aledo field is given over to a comparison of the effectiveness of different carriers of phosphorus.

In this experiment each series contains four plots. Plot 1 receives residues treatment only; Plot 2 receives residues and phosphorus in one of the forms under test; Plot 3 receives residues, limestone, and phosphorus; and Plot 4 is similar to Plot 3 with phosphorus omitted. On one series steamed bone meal is used as the carrier of phosphorus and is applied at the rate of 200 pounds per acre per year. On another series superphosphate is applied at the yearly rate of 333⅓ pounds per acre. On a third series rock phosphate serves as the source of phosphorus and is applied at the rate of 666⅔ pounds per acre per year. On the last series basic slag phosphate is applied at the rate of 250 pounds per acre per year.

The yields for all crops harvested on these plots are recorded in Table 8. Table 9, which is derived from Table 8, shows the value of the increase in crop yield presumed to have resulted from applying the various forms of phosphatic fertilizers for the 13 crops harvested since the beginning of the applications up to 1928. In computing these comparisons, each phosphate plot is compared with its neighboring non-phosphate plot. Aside from the soybeans, the figures show without exception more or less crop increase on the phosphorus plots, no matter what the form of carrier employed.

The difficulty in arriving at a general conclusion regarding the comparative economy in the use of these different phosphorus materials is obvious, for all depends upon their relative cost, which fluctuates from time to time. Furthermore, the prices received from farm produce likewise fluctuate; and to complicate matters still further, these fluctuations do not necessarily run parallel with those of the fertilizer cost. However, one may compute for himself the relative economy of producing these crop increases by applying any set of prices for crops and fertilizers which appear to be most applicable according to prevailing market conditions. For the purpose of furnishing an illustration

TABLE 8.—ALEDO FIELD: PHOSPHATE EXPERIMENT

Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1916[1] Corn	1917[1] Oats	1918[1] Soy-beans	1919 Wheat	1920 Corn	1921 Oats	1922 Clover hay	1923 Corn	1924 Corn	1925 Oats	1926 Wheat	1927 Corn	1928 Corn
501	R.....	53.4	85.5	18.9	32.4	72.8	48.9	(2.88)	83.5	58.2	63.9	44.0	33.9	69.8
502	RbP....	61.7	91.7	19.0	34.7	86.4	61.9	(3.25)	82.7	66.0	75.0	59.2	63.2	71.7
503	RLbP...	61.5	90.6	23.2	35.6	87.3	53.3	(3.48)	82.5	66.8	73.4	62.0	71.3	78.3
504	RL.....	55.1	80.5	22.6	32.9	77.7	47.7	(2.61)	88.2	60.3	64.5	44.6	58.5	72.0
601	R.....	55.2	84.7	19.5	33.0	71.2	53.6	(3.17)	84.7	57.3	64.4	43.3	37.2	71.3
602	RsP....	57.8	87.7	18.7	38.3	87.1	60.9	(3.23)	82.5	65.9	76.1	60.6	54.8	73.2
603	RLsP...	64.7	83.4	23.1	38.2	88.1	52.3	(3.53)	77.6	64.7	78.1	64.4	67.0	74.9
604	RL.....	51.9	81.7	24.6	32.8	84.9	50.2	(3.06)	84.1	51.9	64.1	47.3	60.8	74.4
701	R.....	54.3	83.1	20.8	34.2	75.6	52.8	(3.41)	82.8	61.2	66.6	44.8	39.9	72.3
702	RrP	58.8	83.3	23.3	36.7	80.4	63.0	(3.60)	87.8	69.3	70.3	59.2	61.8	74.3
703	RLrP...	57.2	81.2	28.1	36.7	80.2	53.3	(3.82)	86.6	70.8	67.8	57.5	67.8	76.5
704	RL.....	52.1	81.7	26.9	34.1	82.0	48.9	(3.15)	84.6	62.5	66.3	48.8	63.0	74.6
801	R.....	57.6	73.8	18.0	33.7	68.1	54.8	(2.62)	74.3	58.8	45.0	45.8	42.2	70.4
802	RslP....	56.4	87.8	20.6	38.1	81.0	66.2	(3.66)	80.0	69.1	66.3	60.2	60.7	69.3
803	RLslP..	53.3	78.9	23.7	38.4	83.6	57.0	(3.63)	82.0	70.2	66.7	66.0	73.1	71.0
804	RL.....	51.8	77.5	21.8	33.3	70.4	59.8	(2.99)	82.6	59.9	53.9	48.2	60.4	75.1

[1]No residues.

of such a computation, the December 1 market quotations for the years in which the respective crops were actually produced have been applied to the results of these Aledo plots. The value of soybeans is arbitrarily set at $1.50 a bushel. For the cost of fertilizer materials the prices of phosphates are estimated as follows: bone meal, $40 a ton; superphosphate, $24; rock phosphate, $12; and slag phosphate, $20 a ton.

Reckoned on the basis of the above prices, it appears from the last column of Table 9 that slag phosphate has produced the most profitable returns of the four phosphorus carriers in the test, bringing an average profit of $4.89 an acre yearly where applied without limestone and $3.57 where applied with limestone. Bone meal has given an average profit of $2.45 applied without limestone and $1.92 applied with limestone. Superphosphate has returned $1.54 used without limestone and $1.21 used with limestone. Rock phosphate has produced a profit of $1.22 an acre a year when applied without limestone and a loss of 55 cents when used with limestone.

In considering these results, it may be pointed out that the quantities of phosphatic materials employed in these experiments are, with the possible exception of the slag phosphate, greater than ordinarily would be used, or need to be used, in good farm practice. Moreover, no consideration is given in these comparisons to the relative phosphorus reserves which should have accumulated in the soil. Finally, it should be emphasized that the order of these values might be easily shifted by relatively small change in commodity prices.

Limestone at the rate of 4 tons an acre was applied to Plots 3 and 4 in 1912 when the land was still under alfalfa, and another dressing was added in 1917 after the present experiments were under way. The results from the limestone treatment are shown in Table 10.

TABLE 9.—ALEDO FIELD: PHOSPHATE EXPERIMENTS

Value of Crop Increases Produced by the Various Forms of Phosphate, Computed from Yields in Table 8

Comparison of treatments	Wheat *2 crops*	Corn *6 crops*	Oats *3 crops*	Clover *1 crop*	Soybeans *1 crop*	Total increase *13 crops*	Cost of phosphate *13 years*	Profit from *13 crops*	Profit per acre per year
Bone meal, residues, *over* residues	$23.35	$44.04	$11.67	$ 4.63	$ .15	$83.83	$52.00	$31.83	$2.45
Bone meal, residues, lime, *over* residues, lime	26.90	27.01	11.31	10.88	.90	77.00	52.00	25.00	1.92
Superphosphate, residues, *over* residues	32.23	32.12	8.15	.75	−1.20	72.05	52.00	20.05	1.54
Superphosphate, residues, lime, *over* residues, lime	32.20	25.33	6.62	5.88	−2.25	67.77	52.00	15.77	1.21
Rock phosphate, residues, *over* residues	22.81	34.51	4.38	2.38	3.75	67.83	52.00	15.83	1.22
Rock phosphate, residues, lime, *over* residues, lime	16.07	17.15	1.49	8.38	1.80	44.89	52.00	− 7.11	− .55
Slag phosphate, residues, *over* residues	26.80	32.46	19.86	13.00	3.90	96.02	32.50	63.52	4.89
Slag phosphate, residues, lime, *over* residues, lime	32.43	24.59	11.07	8.00	2.85	78.94	32.50	46.44	3.57

At the prices for produce and limestone assumed in these computations, a profit of $1.69 an acre a year for limestone applied without phosphate of any kind is found. Where limestone was applied with bone meal, the limestone

TABLE 10.—ALEDO FIELD: PHOSPHATE EXPERIMENTS

Value of Crop Increases Produced by Limestone, Computed From Yields in Table 8

Comparison of treatments	Wheat *2 crops*	Corn *6 crops*	Oats *3 crops*	Clover *1 crop*	Soybeans *1 crop*	Total increase *13 crops*	Cost of limestone[1] *13 years*	Profit from *13 crops*	Profit per acre per year
Limestone, residues, *over* residues	$3.25	$22.14	$− .40	$− .84	$7.01	$31.16	$9.18	$21.98	$1.69
Limestone, residues, bone meal, *over* residues, bone meal	5.31	11.35	−3.76	2.88	6.30	22.08	9.18	12.90	.99
Limestone, residues, superphosphate, *over* residues, superphosphate	4.43	11.93	−4.58	3.75	6.60	22.02	9.18	12.84	.99
Limestone, residues, rock phosphate, *over* residues, rock phosphate	− 2.07	5.00	−5.04	2.75	7.20	7.84	9.18	− 1.34	−.10
Limestone, residues, slag phosphate, *over* residues, slag phosphate	7.71	11.26	−1.81	−.38	4.65	21.44	9.18	12.26	.94

[1]Owing to the fact that the first application of limestone on these plots was made for alfalfa four years before the present experiments were started, the total expense of $12 an acre for limestone is prorated, leaving a charge of $9.18 for the 13 crops involved in the present experiments.

profit was 99 cents an acre a year, and with superphosphate it was likewise 99 cents an acre. Used with rock phosphate, the crop increases were so small that there was a loss of 10 cents an acre a year. Applied with slag phosphate, the returns show a profit of 94 cents an acre a year.

It appears, therefore, that by distributing the cost of the limestone over the years since its first application, this material has returned a moderate profit except where used with rock phosphate.

It should be observed that the Aledo field represents one of those borderline cases, so to speak, in which the upper soil is nearly neutral or only slightly acid and the lime requirement, therefore, is not very marked. As time goes on, however, and cropping continues, a greater need for lime will probably develop. By discontinuing liming on these plots the annual cost of the limestone already applied is automatically reduced, so that net returns which hitherto have perhaps represented an actual loss may sooner or later result in a positive profit.

THE MORROW PLOTS

As representing the soil type Brown Silt Loam, the field experiments on the Morrow Plots, which have been continued for more than half a century, will be of special interest.

The Morrow Plots are located on the campus of the University of Illinois. This series now consists of three plots divided into halves, and the halves are subdivided into quarters. On one plot, corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904. Besides farm manure, phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. In 1925 the phosphates were evened up to a total of 3,300 pounds of bone meal and 13,200 pounds of rock phosphate and their application discontinued. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre. From 1903 until 1920, legumes were seeded in the corn on the south half of each plot. Legumes, chiefly red clover until 1918 and sweet clover since that time, have been seeded in the oats on the south half of Plot 4.

Summarizing the data from these Morrow plots into two periods, with the second period beginning in 1904, when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the untreated, continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oat production. The averages for the three-year system on the untreated land show a slight increase in corn yield, a small decrease in oats, and a considerable reduction in clover.

TABLE 11.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY

Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-Year Rotation		
			Corn	Oats	Corn	Oats	Clover[1]
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None.....	39.7	41.0	44.0	48.0	47.6	(2.03)
		25 crops	*12 crops*	*13 crops*	*9 crops*	*8 crops*	*8 crops*
1904 to 1928	None.....	25 0	35.1	34.0	49.3	45.1	(1.49)
	MLP.....	40.2	60.6	59.2	67.2	62.7	(2.83)

[1]Including all legume crops evaluated as clover hay.

Crop rotation has noticeably improved the yields over continuous corn growing. The three-year rotation has been more effective than the two-year rotation in maintaining yields over the entire period. The two-year rotation, however, has been gaining on the three-year rotation in recent years probably because of the influence of sweet clover.

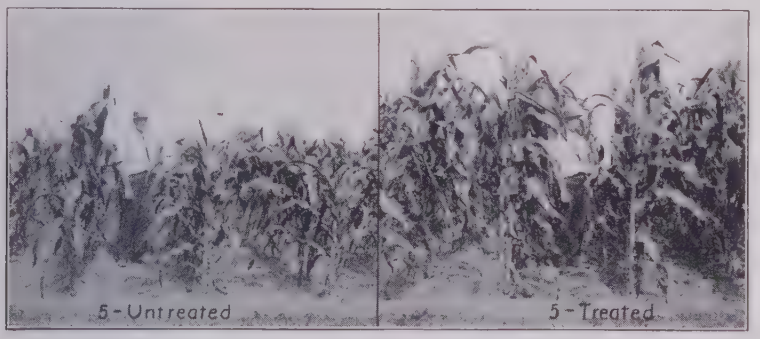


FIG. 8.—CORN ON THE MORROW PLOTS IN THE THREE-YEAR ROTATION

Both of these plots are under a good crop rotation of corn, oats, and clover. No soil treatment is applied to the plot at the left, while that at the right receives manure, limestone, and phosphate. The one is yielding at the rate of 50 bushels an acre, the other at 67 bushels.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

Thruout the season the crops growing on the treated soil are usually at a more advanced stage of development than those growing on the untreated soil. In corn this shows up at husking time in drier, sounder ears than those found on the untreated land.

An important principle of soil management is demonstrated in these experiments; namely, that the best results are not obtained thru crop rotation alone nor thru soil fertilization alone, but it is the combination of these two practices that brings out the highest possibilities for production.

The practices in rotation and soil treatment which have been the most effective in increasing the crop-producing capacity of the soil have also been the most

profitable financially. These better practices not only have increased the yields but they have made possible a greater economy in production, an important factor in increasing farm profits.

For further information concerning these long-time soil experiments, the reader is referred to Bulletin 300, "Lessons from the Morrow Plots," where these investigations are described and discussed in detail.

THE KEWANEE FIELD

The Kewanee experiment field, representing the soil type Brown Silt Loam, is located in Henry county about midway between Kewanee and Galva. This field has been in operation since 1915. It includes 20 acres of the dark-colored loessial soil characteristic of the region. Altho the main soil type represented is Brown Silt Loam, a detailed examination reveals the presence of a second type occupying the basin of the draw which traverses the field in a winding direction. This minor type is classified as Black Clay Loam On Drab Clay. The topography of the land is rather rolling and it has a tendency to wash at certain spots. The field is laid out in two systems of plots designated as the Major and the Minor series.

The Major Series

A rotation system of wheat, corn, oats, and clover has been practiced on the Major series, the crops being managed mainly as described on page 38. Since 1921 the clover on the residues plots has been harvested for hay instead of seed and the oat straw has not been returned to the land. Since 1922 the periodic application of limestone has been suspended after the different series had received an average total of 6¾ tons to the acre, and no more is to be applied until it is needed again. The practice of returning the wheat straw has been discontinued since 1922, and since 1925 only one crop of clover hay on the residues plots has been removed, the second crop being plowed down as green manure. The phosphate applications were suspended in 1927 after evening up all phosphate plots to a total of 4 tons per acre.

Table 12 gives a summary of the results showing the average annual yields for the different kinds of crops, including the years since the complete soil treatments have been in effect.

In looking over these results one may observe first the effect of animal manure, which has given profitable increases in all the crops. Residues alone show no significant effect.

Limestone in addition to manure has resulted in a small improvement, probably sufficient to cover the cost. It has been somewhat more effective in the grain system than in the livestock system.

Phosphorus, as usual, shows up in these averages to best advantage on the wheat crop in the residues system. Where used with manure and limestone, little effect was produced except on the wheat; but where used with residues and limestone, fair increases were produced in all crops, sufficient to return a financial profit under present market conditions. A study of the detailed data reveals a fact of interest in this connection which these averages do not bring out,

TABLE 12.—KEWANEE FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1917-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *10 crops*	Corn *12 crops*	Oats *12 crops*	Clover[1] *11 crops*
1	0	29.0	54.6	59.0	(1.64)
2	M	32.4	66.0	71.0	(2.23)
3	ML	35.2	70.6	73.2	(2.30)
4	MLP	40.0	72.1	72.4	(2.48)
5	0	30.3	56.1	60.6	(1.56)
6	R	31.6	58.2	59.6	(1.46)
7	RL	34.2	66.5	63.3	(1.71)
8	RLP	39.8	70.9	69.0	(1.89)
9	RLPK	40.6	74.4	70.6	(1.97)
10	0	28.1	50.3	56.4	(1.29)
	Crop Increases				
	M over 0	3.4	11.4	12.0	(.59)
	R over 0	1.3	2.1	− 1.0	−(.10)
	ML over M	2.8	4.6	2.2	(.07)
	RL over R	2.6	8.3	3.7	(.25)
	MLP over ML	4.8	1.5	− .8	(.18)
	RLP over RL	5.6	4.4	5.7	(.18)
	RLPK over RLP	.8	3.5	1.6	(.08)

[1]Including some seed evaluated as hay.

and that is that the phosphate exerted very little influence during the earlier years of the experiments. Within the past seven or eight years, however, the phosphorus treatment has come suddenly into evidence and the trend of its effectiveness seems at present to be on the upgrade.

No significant response appears as the result of potassium fertilization, thus indicating the futility of purchasing potassium fertilizer for use in this kind of a cropping system on this kind of soil.

Comparative Phosphate Experiments

Four short series having only 4 plots each constitute the so-called Minor system on the Kewanee field. These plots are now given over to a comparison of the effectiveness of rock phosphate and superphosphate.

Alfalfa was grown on these plots until 1922. In the beginning, limestone was applied to Plots 3 and 4 at the rate of 4 tons an acre. This application was repeated in 1919. In 1922 the present experiments with phosphates were begun and the same rotation practiced on the larger series described above was established on these series. In this comparison rock phosphate is used on Plots 1 and 3 at the annual rate of 400 pounds an acre, applied once in the rotation ahead of the wheat, but beginning with 1927 rock phosphate will be applied at the same time as the superphosphate. Superphosphate is used on Plots 2 and 4 at the annual rate of 200 pounds an acre. It is applied twice in the rotation, one-half for wheat and one-half for oats. A summary of the annual crop yields and corresponding money values is given in Table 13.

TABLE 13.—KEWANEE FIELD: PHOSPHATE EXPERIMENT
Average Annual Crop Yields and Corresponding Money Values 1922-1928
Bushels or (tons) per acre

Soil treatment applied	Wheat *7 crops*	Corn *7 crops*	Oats *7 crops*	Legume hay *7 crops*	Value per acre
Residues, rock phosphate	43.3	74.1	76.5	3.09	$43.89
Residues, superphosphate	45.1	73.0	78.2	3.02	44.17
Residues, limestone, rock phosphate	38.8	73.0	73.5	3.09	42.05
Residues, limestone, superphosphate	46.6	75.1	77.0	3.01	44.83

In comparing these two forms of phosphate the following set of prices are assumed as representing the average market conditions for the past seven years (December 1 quotations): wheat, $1.21 a bushel; corn, 68 cents; oats, 39 cents; and hay, $13.90 a ton. For the cost of two phosphorus carriers, an estimate of $12 a ton for rock phosphate and $24 a ton for superphosphate may be taken, thus making the expense for the two kinds of phosphate equal.

With these prices applied to the yields given in Table 13, it is found that without limestone there is very little difference in value of crops produced under the two forms of phosphate. The 38 cents in favor of the superphosphate is scarcely significant in view of the experimental errors involved in this sort of tests. In the presence of limestone the difference in crop values is $2.78 per acre per year in favor of superphosphate. Wheat has been the crop most affected by the form of phosphate applied.

It is to be borne in mind that the order of values can easily be shifted by a change in the relative yields of the respective crops or by a change in commodity prices. Furthermore no consideration has been given here to any possible difference in the residual effects of the two forms of phosphate which might appear upon discontinuing the treatments.

THE BLOOMINGTON FIELD

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat; and, since 1905, they have been grown in the sequence named.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. For 20 years all of the phosphorus on this field was applied in the form of steamed bone meal at the rate of 200 pounds an acre a year.

Table 14 presents a summary of the work to 1923 by average annual yields. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they were applied.

The value of limestone on this field is difficult to assess on account of the erratic results found upon comparing Plots 1 and 2. Here both corn and wheat

TABLE 14.—BLOOMINGTON FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1902-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*	Clover[1] *3 crops*
1	0	44.6	40.6	26.5	(.74)
2	L	41.5	44.7	24.1	(.80)
3	LR	47.5	46.2	27.9	(.88)
4	LbP	55.8	54.3	45.7	(2.54)
5	LK	46.2	43.5	25.5	(.90)
6	LRbP	60.6	66.0	49.7	(1.19)
7	LRK	48.6	46.8	27.5	(.82)
8	LbPK	60.9	57.2	44.5	(2.44)
9	LRbPK	64.2	63.1	50.4	(.81)
10	RbPK	58.8	52.8	49.3	(.83)
	Crop Increases				
For limestone					
L	over 0	− 3.5	4.1	− 2.4	(.06)
LRbPK	over RbPK	5.4	10.3	1.1	−(.02)
For residues					
LR	over L	6.0	1.5	3.8	(.08)
LRbP	over LbP	4.8	11.7	4.0	−(1.35)
LRK	over LK	2.4	3.3	2.0	−(.08)
LRbPK	over LbPK	3.3	5.9	5.9	−(1.63)
For phosphorus					
LbP	over L	14.3	9.6	21.6	(1.74)
LRbP	over LR	13.1	19.8	21.8	(.31)
LbPK	over LK	14.7	13.7	19.0	(1.54)
LRbPK	over LRK	15.6	16.3	22.9	−(.01)
For potassium					
LK	over L	4.7	− 1.2	1.4	(.10)
LRK	over LR	1.1	.6	− .4	−(.06)
LbPK	over LbP	5.1	2.9	− 1.2	−(.10)
LRbPK	over LRbP	3.6	− 2.9	.7	−(.38)

[1]Two crops of seed on Plots 3, 6, 7, and 9 evaluated as hay.

appear to have suffered from the application of limestone, but the difficulty may well be attributable to soil variability. Comparing Plots 9 and 10, it would appear that in combination with residues, phosphorus, and potassium, the limestone on the whole was beneficial.

The residues treatment, supplying organic matter and nitrogen, shows a beneficial effect on the grain crops, but not on the clover.

The prominent feature of the results on the Bloomington field is the effect of phosphorus. In all of the grain crops on every plot where bone meal was applied, there was a remarkable response to the treatment, as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues, with limestone, residues, and phosphorus) we find that the phosphorus treatment produced an average annual increase in the yield of corn of about 13 bushels an acre, while the yield of oats was increased by about 20 bushels, and that of wheat by about 22 bushels. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8, where potassium instead of residues was present.

Quite different are the results from the use of potassium on this field. The potassium was applied mainly in the form of potassium sulfate, but in 1917 when this material became unavailable thru war conditions, potassium carbonate was substituted. There was a moderate increase in the corn yield where potassium was used and particularly where residues were absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is the outstanding limiting factor in production and the application of this element in the form of steamed bone meal is attended by a high financial profit.

New Phosphate Experiments

In view of this remarkable response to bone meal on the Bloomington field, it was of interest to know how other carriers of phosphorus would behave, and accordingly some experiments were planned to investigate this question. For this purpose, the plots were divided in 1924 and certain new treatments were applied in order to compare the effects of rock phosphate and of superphosphate with bone meal, and at the same time to determine the residual effect of the accumulated phosphorus resulting from the continuous application of the bone meal in presumably somewhat excessive amounts.

The following modifications of the original plots were introduced:

An extra plot, No. 11, was added to the series and all plots were divided into north and south halves. Residues including cornstalks, the second crop of red clover, and other leguminous green manure crops are plowed down on all plots except Plot 1-S. Different phosphorus carriers are applied at the following acre rates per rotation: bone meal, 1000 pounds, to Plots 2-N, 4-N, 6-N, 8-N, 9-N, and 10-N; rock phosphate, 2500 pounds, to Plots 3-N, 5-N, 7-N, and 11-N; superphosphate, 1000 pounds, to Plots 3-S, 5-S, 7-S, and 11-S. Two-fifths of the rotation application of these phosphates are made preceding the oats crop, two-fifths ahead of the wheat crop, and one-fifth in preparation for the corn crop.

Table 15 indicates the arrangement of these modified plots and also gives the results of the five years in which these later experiments have been in progress.

In arriving at the financial results presented in the table, the values of the crops are based upon December 1 farm price quotations for the years in which the respective crops were produced. In deducting the annual cost for the different treatments, the total amounts of materials applied during the entire period of operation on the field were prorated. The expense for limestone is reckoned here at $3 a ton, rock phosphate at $14, superphosphate at $28, bone meal at $48, and residues at 75 cents an acre.

It should be mentioned in considering the results that the soil of these plots is rather variable, with little provision for duplication; and also that some of the treatments are not now strictly comparable with one another on account of the previous history of the plots. Nevertheless, making allowances for these

TABLE 15.—BLOOMINGTON FIELD: NEW PHOSPHATE EXPERIMENTS
Crop Yields and Values 1924-1928—Bushels or (tons) and dollars per acre

Plot No.	Soil treatment applied		1924	1925	1926	1927	1928	Average annual acre values		
	Previous	Present	Oats	Clover	Wheat	Corn	Corn	Gross	Cost of treatment	Net
1-N	0.....	R.....	60.6	(.79)	29.3	49.8	49.0	$29.29	$ .75	$28.54
1-S	0.....	0.....	58.4	(2.54)	19.5	41.0	33.4	28.82	.....	28.82
2-N	L.....	RLP (bone)...	72.6	(1.63)	35.0	58.6	52.2	36.18	6.55	29.63
2-S	L.....	RL.....	53.2	(.75)	18.7	46.0	35.2	23.41	1.75	21.66
3-N	RL.....	RLP (rock)....	68.2	(2.18)	32.5	63.6	64.6	39.35	5.25	34.10
3-S	RL.....	RLP (super)...	71.3	(1.74)	41.0	67.6	59.6	40.18	4.55	35.63
4-N	LP (bone)....	RLP (bone)[1]...	57.6	(1.81)	37.3	60.0	49.6	35.79	6.55	29.24
4-S	LP (bone)....	RLP (bone)[2]...	67.2	(1.89)	36.7	63.6	60.0	38.71	5.30	33.41
5-N	LK.....	RLKP (rock)..	63.2	(1.66)	32.5	61.4	56.2	35.73	7.65	28.08
5-S	LK.....	RLKP (super).	78.4	(1.59)	40.7	69.4	55.6	39.99	6.95	33.04
6-N	RLP (bone) ..	RLP (bone)[1]...	68.8	(2.18)	40.5	60.8	55.8	39.73	6.55	33.18
6-S	RLP (bone) ..	RLP (bone)[2]...	71.6	(2.21)	40.0	64.2	60.4	41.09	5.30	35.79
7-N	RLK.....	RLKP (rock)..	71.2	(2.11)	35.3	66.4	58.4	39.62	7.65	31.97
7-S	RLK.....	RLKP (super).	80.9	(1.66)	40.7	74.8	62.8	42.23	6.95	35.28
8-N	LKP (bone)..	RLKP (bone)[1].	60.9	(1.69)	39.2	67.4	56.2	38.10	8.95	29.15
8-S	LKP (bone)..	RLKP (bone)[2].	65.0	(1.59)	36.0	69.4	63.0	38.62	7.70	30.92
9-N	RLKP (bone)	RLKP (bone)[1].	60.9	(2.18)	43.8	75.8	60.4	42.56	8.95	33.61
9-S	RLKP (bone)	RLKP (bone)[2].	72.2	(1.65)	41.5	77.8	62.6	41.97	7.70	34.27
10-N	RKP (bone)..	RKP (bone)[1]...	48.2	(1.93)	45.7	56.6	51.2	37.02	7.95	29.07
10-S	RKP (bone)..	RKP (bone)[2]...	51.2	(1.53)	43.0	60.6	58.0	36.89	6.70	29.99
11-N	([3])	RP (rock).....	70.4	(1.68)	45.3	61.8	47.4	38.43	4.25	34.18
11-S	([3])	RP (super)....	60.0	(1.78)	44.5	63.0	57.2	39.11	3.55	35.56

[1]Bone meal applications omitted from 1917 to 1924. [2]No bone meal applied since 1917. [3]New plot added in 1924.

facts, certain figures in the last column of the table showing the net average acre value per year indicate effects worthy of consideration.

In answering the question as to whether other carriers of phosphorus would be as effective as the bone meal in building up this soil, attention is called to the results on Plots 2-N, 3-N, and 3-S where bone meal, rock phosphate, and superphosphate respectively have been employed in addition to limestone and residues. Unfortunately the comparison here is not altogether perfect in that the residues treatment on Plot 2-N was not introduced until 1924, whereas the other two plots had been under residues in the old system before the present experiments were begun and may, therefore, have an advantage in this respect over the bone-meal plot. However this may be, the results as they stand at present place both rock phosphate and superphosphate ahead of bone meal.

Between rock phosphate and superphosphate four direct comparisons in different combinations with other materials are afforded (Plots 3, 5, 7, and 11.) In some years on some plots the results are in favor of superphosphate; in other years on the same plots the reverse is true. As the results stand at present, the majority are in favor of superphosphate but their inconsistency makes it difficult to come to any final conclusion. It may be noted that in these com-

parisons the two materials are not applied in amounts proportionate to equal cost as in other cases reported. Here 200 pounds per acre per year of superphosphate figured at $2.80 are applied against 500 pounds of rock phosphate valued at $3.50 per acre per year.

For light on the question of residual effect of accumulated phosphorus in the soil, attention is called to the results on Plots 4, 6, 8, 9, and 10, where the north half-plots are now regularly receiving bone meal, while the south halves have received none since 1917. Invariably the net return is higher on the south half, thus indicating that the reserve phosphate accumulated in the soil from previous applications is still exerting a beneficial effect that is more than adequate to offset the expense involved in renewed applications.

By way of a summary of the main lessons brought out at this time by the Bloomington experiments, the following statements may be made.

The results indicate an outstanding phosphorus hunger.

This phosphorus need is satisfied by the application of either bone meal, rock phosphate, or superphosphate.

There is a pronounced residual effect from previous excessive applications of phosphorus carried in the form of bone meal.

THE MINONK FIELD

A University experiment field representing the soil type Black Clay Loam On Drab Clay is located in Woodford county near Minonk. This field was established in 1910. It comprizes 15 acres of dark-colored prairie soil of loessial and drift origin. The experiment plots lie mainly on Black Clay Loam On Drab Clay, altho a detailed examination reveals the presence of three other soil types distinguishable on account of certain profile characteristics. These are Brown Silt Loam, Brown Silt Loam On Calcareous Drift, and Brown Silt Loam On Calcareous Clay.

The field is laid out into four series of 10 plots each. The plots are one-fifth acre in size except in Series 100, where they are one-tenth acre. A crop rotation of corn, oats, clover, and wheat was practiced until 1923, when it was changed to corn, corn, oats, and wheat, with a seeding of hubam clover in the oats on all plots and biennial sweet clover in the wheat on the residues plots. In 1921 the practice of returning the oat straw on the residues plots was discontinued, and in 1922 the return of the wheat straw was likewise discontinued. Up to that time limestone, varying in total quantity from 7½ to 9 tons an acre on the different series, had been applied. These applications were then suspended until such time as the need for more lime becomes apparent. The applications of rock phosphate were likewise indefinitely suspended in 1923 after evening up the total applications to 4 tons an acre on all the phosphate plots.

The average annual yields of all crops produced since the complete soil treatments have been in effect are given in Table 16.

In looking over these results, one observes from the good yields on the untreated plots the naturally high productiveness of this land. There is more or less response to farm manure; in the corn the yield is markedly increased by its use. Residues alone have likewise increased the yields of the grain crops.

TABLE 16.—MINONK FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1912-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Corn	Oats	Clover[1]	Soybeans	Stubble clover	
							Hubam	Sweet clover
		14 crops	*23 crops*	*16 crops*	*5 crops*	*4 crops*	*2 crops*	*2 crops*
1	0	30.1	50.2	58.8	(2.58)	19.3	(.72)	.....
2	M	33.8	60.6	61.3	(2.81)	20.5	(.94)	.....
3	ML	32.4	61.0	60.3	(2.74)	21.7	(.83)	.....
4	MLP	34.4	61.0	59.2	(2.93)	21.0	(.97)	.....
5	0	31.4	48.6	55.5	(1.36)	20.7	(.86)	.....
6	R	33.8	59.3	61.7	(1.50)	20.6	(.91)	(1.19)
7	RL	30.8	61.1	61.6	(1.51)	19.3	(.90)	(1.16)
8	RLP	32.7	62.3	63.0	(1.47)	19.7	(1.06)	(1.33)
9	RLPK	32.0	59.9	63.2	(1.49)	17.2	(1.20)	(1.50)
10	0	26.1	44.0	55.2	(2.30)	15.3	(.58)	.....
	Crop Increases							
	M over 0	3.7	10.4	2.5	(.23)	1.2	(.22)	.....
	R over 0	2.4	10.7	6.2	(.14)	− .1	(.05)	(1.19)
	ML over M	− 1.2	.4	− 1.0	−(.07)	1.2	−(.11)	.....
	RL over R	− 3.0	1.8	− .1	(.01)	− 1.3	−(.01)	−(.03)
	MLP over ML	2.0	0.0	− 1.1	(.19)	− .7	(.14)	.....
	RLP over RL	1.9	1.2	1.4	−(.04)	.4	(.16)	(.17)
	RLPK over RLP	− .7	− 2.4	.2	(.02)	− 2.5	(.14)	(.17)

[1]Including some seed evaluated as hay.

Limestone seems to have had no material effect on crop yields. Evidently this soil does not need lime. The use of rock phosphate has not been profitable either in the manure or the residues system. Potassium, as used in these experiments, has likewise been ineffective.

These results therefore indicate the advisability of furnishing plenty of organic matter, either thru stable manure or thru crop residues, including leguminous green manure, as the best practical means, for the present, of improving the productiveness of this naturally fertile soil. As time goes on, with changing soil conditions and shifting market values, the situation may develop under which a different recommendation will be warranted.

THE HARTSBURG FIELD

Black Clay Loam as noted on page 6, occupies nearly 70 square miles in Douglas county. The results of the Hartsburg field, situated in Logan county just east of the town of Hartsburg, are suggestive of the treatments that are effective on this type of soil.

The Hartsburg field was started in 1911. It is laid off in five series of 10 plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series.

The crops were handled mainly as described on page 38 until 1918 when it was planned to remove one hay crop and one seed crop of clover from the residues plots. In 1921 it was decided to harvest all the clover as hay. At that time the

TABLE 17.—HARTSBURG FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1913-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat 13 crops	Barley 1 crop	Corn 24 crops	Oats 17 crops	Clover 7 crops	Soybeans 2 crops	Alfalfa 8 crops	Stubble clover: Hubam 1 crop	Stubble clover: Sweet clover 1 crop
1	0	24.9	35.4	48.1	48.1	(1.84)	(1.29)	(3.47)	(.83)	.....
2	M	29.2	44.2	58.8	52.9	(2.16)	(1.64)	(3.67)	(1.15)	.....
3	ML	34.0	50.0	64.5	58.3	(2.32)	(1.82)	(3.91)	(.91)	.....
4	MLP	36.2	50.0	63.8	57.8	(2.39)	(1.92)	(4.19)	(1.17)	.....
5	0	29.7	42.7	53.3	47.0	(1.28)	25.8	(3.33)	(.71)	.....
6	R	32.7	47.5	63.7	53.3	(1.67)	26.8	(3.78)	(.75)	(.85)
7	RL	30.1	53.3	66.9	51.3	(1.64)	28.4	(3.45)	(.68)	(.75)
8	RLP	34.3	46.9	67.3	55.4	(1.79)	26.1	(4.04)	(.72)	(.90)
9	RLPK	33.4	55.6	65.4	54.5	(1.70)	26.4	(4.16)	(.80)	(1.00)
10	0	30.5	45.8	52.8	48.0	(2.02)	(1.69)	(3.20)	(.75)	.....
	Crop Increases									
	M over 0	4.3	8.8	10.7	4.8	(.32)	(.35)	(.20)	(.32)	.....
	R over 0	3.0	4.8	10.4	6.3	(.39)	1.0	(.45)	(.04)	(.85)
	ML over M	4.8	5.8	5.7	5.4	(.16)	(.18)	(.24)	−(.24)	.....
	RL over R	− 2.6	5.8	3.2	− 2.0	−(.03)	1.6	−(.33)	−(.07)	−(.10)
	MLP over ML	2.2	0.0	− .7	− .5	(.07)	(.10)	(.28)	(.26)	.....
	RLP over RL	4.2	− 6.4	.4	4.1	(.15)	− 2.3	(.59)	(.04)	(.15)
	RLPK over RLP	− .9	8.7	− 1.9	− .9	−(.09)	.3	(.12)	(.08)	(.10)

return of the oat straw to the land was discontinued. In 1922 the return of the wheat straw was likewise discontinued. The application of limestone was discontinued in 1922 after amounts ranging from 7½ to 10 tons an acre on the different series had been applied, and no more will be added until further need for it becomes apparent. In 1923 the phosphate applications were evened up to a total of 4 tons an acre on all phosphate plots, and no more will be applied for an indefinite period. At that time the rotation on the first four series was changed to corn, corn, oats, and wheat with a seeding of hubam clover in the oats on all plots, and a seeding of biennial sweet clover in the wheat on the residues plots. The rotation was changed also on the fifth series to corn, oats, wheat, and a mixture of alfalfa with red clover. The soil treatments are as indicated in Table 17, which summarizes by crops the yields for the period during which the plots have been under full treatment.

The outstanding feature of the results on the Hartsburg field is the large increases produced by organic manure whether in the form of crop residues or stable manure. The behavior of limestone is rather peculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure it shows some increase in practically all crops, while with residues its effect on several of the crops appears negative.

Altho rock phosphate has given some increases in wheat yield in both the manure and the residues systems, the results with other crops have been such as to render the use of this material unprofitable on this field. The addition of potassium appears to have produced no significant effect except on the one barley crop.

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 44

COLES COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER,
AND L. H. SMITH

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URBANA, ILLINOIS, AUGUST, 1929

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Coles county was conducted, and Mr. W. P. Hiltabrand, who as leader of the field party, was in direct charge of the mapping.

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COLES COUNTY SOILS

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COLES COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER and L. H. SMITH[1]

LOCATION AND CLIMATE OF COLES COUNTY

Coles county is located in the east-central part of Illinois. It is a medium-sized county, covering 508.84 square miles, over half of which is dark-colored upland soil.

The climate of Coles county is typical of central Illinois. The rainfall is abundant and usually well distributed and, while there is a wide range between the extremes of summer and winter temperature, there are but a few days during the winter when subzero weather prevails. Summer temperatures are, as a rule, not oppressive. The following weather data is taken from the records of the Cooperative Weather Bureau Station at Charleston for the thirteen-year period 1914 to 1927, inclusive.

The greatest range in temperature for any one year during this period was 128 degrees in 1918. The highest temperature recorded was 107°; the lowest, 24° below zero. The average date of the last killing frost in the spring is April 26; the first in the fall, October 16. The average length of the growing season is 173 days.

The average annual rainfall during this thirteen-year period was 38.9 inches, distributed as follows: January, 2.33 inches; February, 1.76; March 3.63; April, 3.53; May, 4.11; June, 3.83; July, 3.21; August, 4.35; September, 4.24; October, 3.35; November, 2.30; December, 3.04.

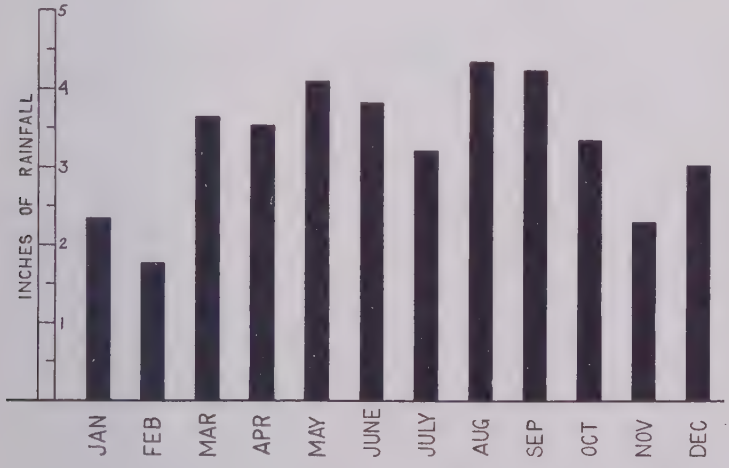

Fig. 1.—The Average Monthly Distribution of Rainfall in Coles County

It will be noted that the more abundant rainfall occurs mainly during the growing season. This, of course, is favorable for crop production.

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AGRICULTURAL PRODUCTION

About 90 percent of the area of Coles county is good agricultural land and suitable for the production of the crops common to the region. Diversified farming is the rule with a relatively large number of beef cattle and hogs produced. The percentage of farms operated by tenants has decreased from 45.7 in 1910 to 41.8 in 1925. The following figures show the acreage and production of the principal crops for Coles county for the year 1924.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	106,010	3,755,975 bu.	37.1 bu.
Wheat	19,080	400,067 bu.	21.0 bu.
Oats	27,698	1,051,514 bu.	38.0 bu.
Timothy	9,438	.....	....
Timothy and clover mixed	8,735	.....	....
Clover	9,948	.....	....
Alfalfa	1,616	.....	....
Total hay	35,021	42,766 tons	1.22 tons
Broom corn	19,250	9,240,000 lbs.	480.0 lbs.

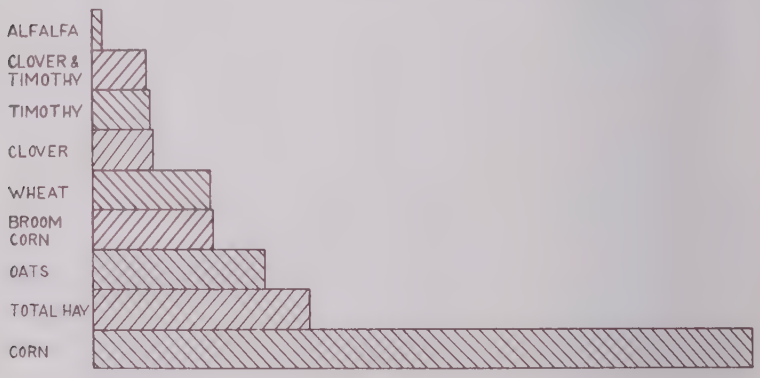


FIG. 2.—RELATIVE ACREAGE OF FIELD CROPS IN COLES COUNTY

The diagram brings out the preponderance of land devoted to the grain crops and broom corn. Legume crops might well occupy a larger proportion of the cultivated acreage. (Data from the 1925 Census.)

These census figures are for a single year only. The following averages for the past ten-year period will probably more nearly represent the true conditions. According to these figures the average yield of corn is 33.6 bushels an acre; wheat, 17.1 bushels; oats, 26.4 bushels; and tame hay, 1.3 tons an acre.

A crop of unusual interest is broom corn, Coles county being in the heart of one of the world's famous broom-corn districts. In production of broom corn this county is far above any other in the state. The acreage given in the above table happens to be unusually high. According to records at hand, it has varied in different years from about 7,000 to over 19,000 acres annually.

Two important crops of rather recent introduction are not mentioned in the above list, namely, soybeans and sweet clover. The increasing interest in soybeans in this section of the country is shown by the fact that last year 5,000 acres in Coles county was devoted to soybeans alone, and on 5,000 other acres soybeans was grown as a companion crop with corn. The great value of sweet clover as a soil-building and pasture crop is becoming more and more recognized.

In 1919, there were only 500 acres of sweet clover in the county; in 1928 the acreage was 15,000.

The following figures show the character of the livestock interests in the county as taken from the census report of 1925.

Animals and Animal Products	*Number*	*Value*
Horses	10,378	$609,912
Mules	2,045	150,270
Cattle (total)	16,861	642,178
Dairy cows	4,981	.....
Dairy products	.....	279,899
Sheep	5,856	57,634
Swine	58,325	733,942
Chickens and eggs	.....	518,599
Wool	.....	12,769

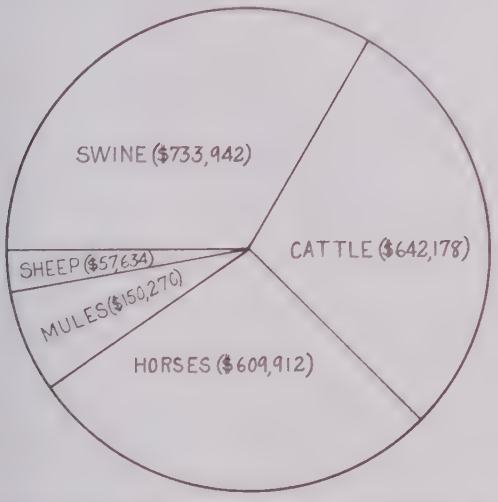


FIG. 3.—RELATIVE VALUE OF THE MORE IMPORTANT CLASSES OF FARM ANIMALS IN COLES COUNTY

Horses, cattle, and swine are the main classes of livestock and are of about equal value in Coles county.

SOIL FORMATION

GEOLOGICAL ASPECTS

One of the most important periods in the geological history of Coles county, from the standpoint of the character of the soils, was the Glacial period. The soils of the county were formed from material laid down during glacial times. Very little wind-blown material occurs in the county other than some formed by the local reworking of fine-textured material.

At least two glacial advances, the Illinoian and early Wisconsin, covered the area that now constitutes Coles county. The glacial debris, known as till or drift, deposited by the Illinoian ice sheet, was buried by the debris deposited by the more recent early Wisconsin ice sheet. Altho the Illinoian drift does not enter into the composition of the soils of Coles county except in the southeast and southwest corners of the county, yet the Illinoian glaciation probably had an important relation to the soils of this county in that it acted as a leveling force, rubbing down the preglacial hills and filling the preglacial valleys.

The terminal moraine of the early Wisconsin glaciation, varying from about 5 to 9 miles in width, extends across the southern part of Coles county. The northern boundary of this moraine is not distinct, while the southern boundary thruout most of its length is marked by an abrupt drop-off. An outwash plain, forming a belt some four or five miles in width, borders the moraine on the south. The outwash plain material lies on an older glaciation. The soils on the outwash plain resemble those to the north more than those to the south, owing to the fact that the material from which they were formed came from the later glaciation.

A considerable portion of Coles county north of the terminal moraine remained for a long period of time under swampy conditions following the retreat of the Wisconsin ice sheet. This condition gave rise to a large proportion of heavy soil with drab-colored subsoil extending for a considerable distance to the north and west of Coles county.

PHYSIOGRAPHY AND DRAINAGE

The portions of Coles county which are occupied by dark-colored soils are for the most part flat to gently undulating. The light-colored area on either side of Kaskaskia river is gently rolling with some small flat areas occurring.

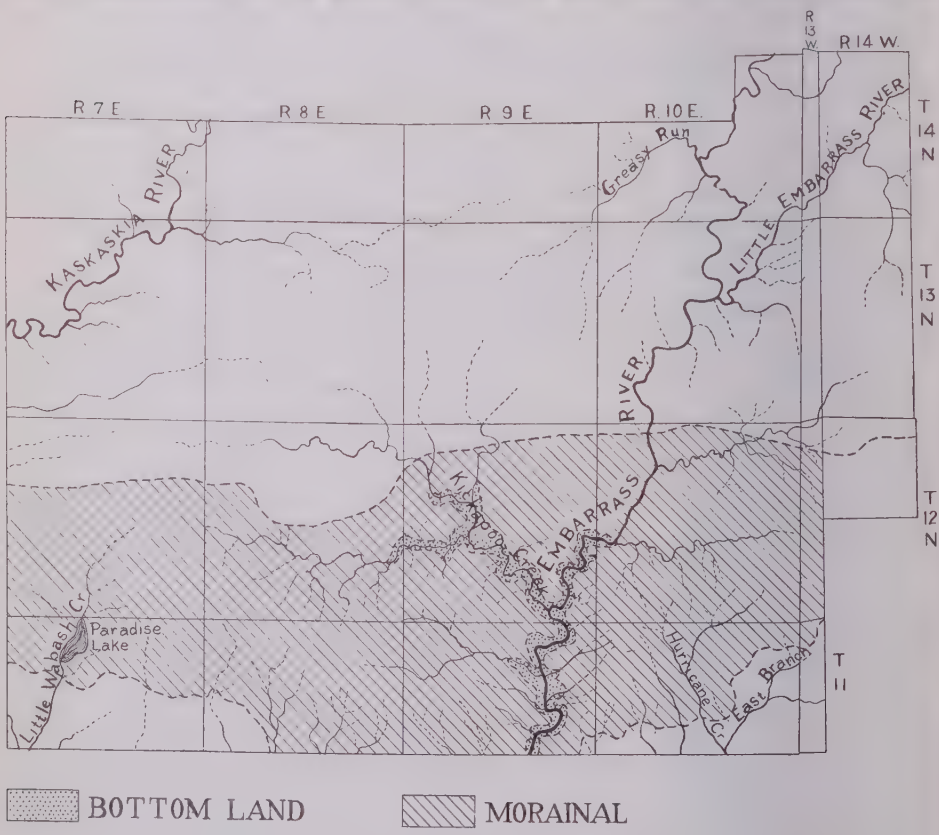


FIG. 4.—DRAINAGE MAP OF COLES COUNTY SHOWING STREAM COURSES AND BOTTOM-LAND AND MORAINAL AREAS

WEST SHEET

LEGEND

300 Lower Illinoisan Glaciation

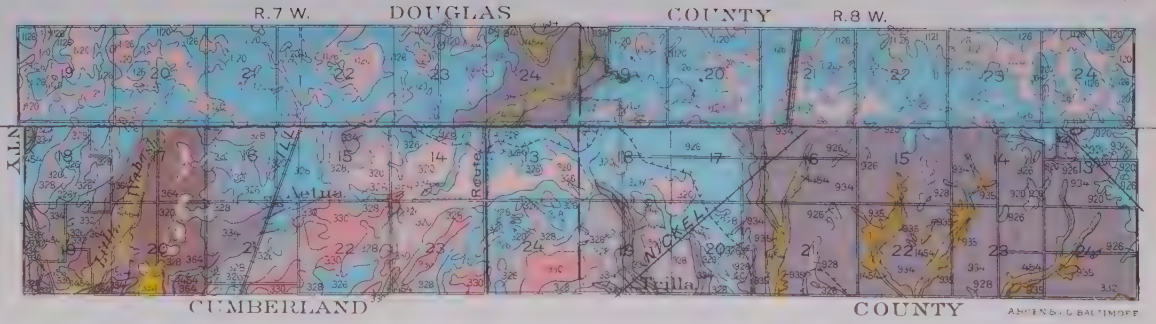
Morainal boundaries

Township lines

Paved roads

Scale

0 ¼ ½ 1 2 Miles



SOIL SURVEY MAP OF COLES COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

while the topography along the Embarrass river, particularly in the southern part of the county, is strongly rolling. The topography of the terminal morainal region, as well as of the small morainal lobe north of Bushton is in general undulating to gently rolling. Apparently the terminal moraine formed a barrier to the drainage until cut thru by Kaskaskia and Embarrass rivers. It was probably during the time when the ice front was retreating to the north that much of the fine sediment from which the heavy soils of this region were formed was laid down.

Most of the drainage of the county is carried by Embarrass and Little Wabash rivers into Wabash river and thence into the Ohio. Kaskaskia river drains the northwest corner of the county, carrying the water southwest into the Mississippi.

The following altitudes at several points in Coles county are given in feet above sea level: Humbolt, 666 feet; Mattoon, 735; Lerna, 754; Charleston, 654; Ashmore, 682; Oakland, 655.

SOIL DEVELOPMENT

A sufficient length of time has elapsed since the ice age for soils to be developed from the materials deposited by the great ice sheets. In Coles county the material from which the soils were formed is largely the ground-up rock known as till or drift. The drift has been locally reworked by wind and water but there appears to have been but little loess deposited over the county. During the long period of time which has elapsed since the retreat of the last ice sheet, the processes of weathering have been acting on the drift, gradually changing it into soil. The soil features, most easily seen, produced by the weathering processes, are the layers or horizons which make up the soil profile.

The horizons are designated by the letters *A*, *B*, and *C* from the surface down. Each of these horizons is usually made up of two or more parts. A more complete discussion of the meaning and designation of horizons will be found on page 23.

Since the upland dark-colored soils of this region have been occupied, probably continuously, by grass vegetation, relatively large amounts of organic matter have accumulated, resulting in the formation of productive dark-colored soils. The areas adjacent to streams, which have been occupied by timber, are light-colored because of the relative deficiency of the surface soil in organic matter. The bottom-land soils are made up, for the most part, of alluvial material brought down from the uplands of the immediate vicinity. These soils are relatively young or immature and therefore have not developed horizons as have the more mature soils of the upland.

SOIL GROUPS

The soils of Coles county are divided into four groups, as follows:

Upland Prairie Soils, dark colored and usually rich in organic matter, the organic matter having been derived from the decaying roots of the wild prairie grasses which occupied this land for thousands of years.

Upland Timber Soils, those zones along stream courses over which forests grew for a long period of time. These contain in general less organic matter than the prairie soils.

Terrace Soils, including bench lands and second bottoms formed by deposits from flooded streams overloaded with sediment, perhaps at the time of the melting of the glaciers.

Swamp and Bottom-Land Soils, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

TABLE 1.—SOIL TYPES OF COLES COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils (300, 900, 1100)			
326 926 1126	Brown Silt Loam[1]	214.12	137 037	42.08
320 920 1120	Black Clay Loam	87.28	55 859	17.15
1121	Drab Clay Loam	1.94	1 242	.38
328 928 1128	Brown-Gray Silt Loam On Tight Clay	8.02	5 133	1.58
330	Gray Silt Loam On Tight Clay	1.91	1 222	.38
		313.27	200 493	61.57
	Upland Timber Soils (300, 900, 1100)			
334 934 1134	Yellow-Gray Silt Loam	134.36	85 990	26.40
335 935 1135	Yellow Silt Loam	29.07	18 605	5.71
332 1132	Light Gray Silt Loam On Tight Clay	.19	122	.04
364	Yellow-Gray Sandy Loam	1.02	653	.20
		164.64	105 370	32.35
	Terrace Soils (1500)			
1526	Brown Silt Loam	1.09	698	.22
1560	Brown Sandy Loam	.16	102	.03
1528	Brown-Gray Silt Loam On Tight Clay Over Gravel	.06	38	.01
1536	Yellow-Gray Silt Loam Over Gravel	3.42	2 189	.67
1564	Yellow-Gray Sandy Loam	.07	45	.01
		4.80	3 072	.94
	Swamp and Bottom-Land Soils (1400)			
1454	Mixed Loam	25.91	16 582	5.10
	Water	.22	141	.04
	Total	508.84	325 658	100.00

[1]Including associated types described in the text but not differentiated on the map.

LEGEND

300 Lower Illinoisan Glaciation

900 Early Wisconsin Moraines

1100 Early Wisconsin Glaciation

1400 Swamp and Bottom Land

1500 Terrace

UPLAND PRAIRIE SOILS

326 926 1126 — Brown Silt Loam

320 920 1120 — Black Clay Loam

1121 — Drab Clay Loam

328 928 1128 — Brown-Gray Silt Loam On Tight Clay

330 — Gray Silt Loam On Tight Clay

UPLAND TIMBER SOILS

334 934 1134 — Yellow-Gray Silt Loam

335 935 1135 — Yellow Silt Loam

332 1132 — Light Gray Silt Loam On Tight Clay

364 — Yellow-Gray Sandy Loam

CONVENTIONAL SIGNS

Swamps

Railroads

Public roads

Private roads

Interurbans

Canals

Moraine boundaries

Township lines

Paved roads

Scale

0 ⅛ ½ 1 2 Miles

SOIL SURVEY MAP OF COLES COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

Table 1 gives the area of each soil type in Coles county and its percentage of the total area. It will be observed that 61.57 percent of the county consists of upland prairie, 32.35 percent of upland timber, .94 percent of terrace soils, and 5.10 percent of swamp and bottom-land soils. The accompanying map, appearing in two sections, shows the location and boundary lines of the various soil types.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix to this Report.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN COLES COUNTY SOILS

Three Depths Represented by Soil Samples

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum, over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.
2. A middle stratum extending from 6⅔ to 20 inches, and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches, and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling, we have represented separately three zones for plant feeding. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow, and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore, it is the only stratum which can be greatly changed in composition as a result of adding fertilizing materials.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires to consider the information in that form. In comparing the composition of the different strata, it must be kept in mind that it is based on different quantities of soil, as indicated above. The figures for the middle and lower strata must, therefore, be divided by two and three respectively before being compared with each other, or with the figures for the upper stratum.

The data in Tables 2, 3, and 4, showing plant-food content of Coles county soils, are based in part upon analyses of samples taken from surrounding counties.

Wide Range in Organic Matter and Nitrogen

It can be readily seen from Table 2 that there is a wide variation among the different soil types of Coles county with respect to their content of the different plant-food elements in the upper 6⅔ inches of soil. The most striking relationship among these variations is observed with respect to organic carbon

and nitrogen, the quantities of which run parallel from type to type tho the organic-carbon content is usually 10 to 12 times as great as the nitrogen. The relationship between organic carbon and nitrogen is explained by the well-established facts that all soil organic matter (or which organic carbon is the measure) contains nitrogen, and that most of the soil nitrogen—usually 99 percent or more—is present in a state of organic combination; that is, as a part of the organic matter.

The upland prairie soils of Coles county are, for the most part, relatively high in organic matter and nitrogen, while the upland timber soils are fairly low, there being little overlapping in the two groups with respect to these constituents. That is, the greatest amount present in the timber soils is about the same as the least amount found in the prairie types. This difference is noticeable not only in the surface soil, but extends to the middle stratum as well. Yellow Silt Loam and Yellow-Gray Sandy Loam are particularly deficient in organic matter and nitrogen. The former type is subject to excessive erosion, which removes the surface soil with its organic-matter accumulation, while the latter, owing to its porous character, permits rapid oxidation of organic matter.

All of the soils of the county diminish rapidly in their content of both organic matter and nitrogen with increasing depth. This diminution is noticeable in the second stratum, 6⅔ to 20 inches, and is very pronounced in the lower stratum, 20 to 40 inches.

Phosphorus Lower in Light-Colored Soils

The total phosphorus content varies somewhat from type to type. It is noticeably low in the lighter colored upland timber soils and high, on the whole, in the upland prairie types. The greatest amount, 1,840 pounds per acre, is to be found in Black Clay Loam. There is a tendency for the phosphorus content of soils to parallel the organic carbon to some extent, but not closely as does nitrogen. Phosphorus, in contrast with some other elements, is not appreciably removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in plant residues at the expense of underlying strata. Investigations at the Illinois Station have shown that in Brown Silt Loam, for example, about 33 percent of the total phosphorus of the surface soil is organic, and in Black Clay Loam about 37 percent. It is the second stratum (6⅔ to 20 inches) which furnishes most of the phosphorus thus moved upward. Consequently, in the soils of Coles county the phosphorus percentage is generally higher in the surface soil than in the second stratum, and frequently higher than in the lower stratum.

Sulfur Generally Well Supplied

Sulfur, another element used by growing plants, is likewise associated to some degree with organic carbon. This is because a considerable, tho varying, proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of organic matter. The soils of Coles county contain from one-half to three-fourths as much sulfur as phosphorus, the amount in the surface soil ranging from 320 to 1,260 pounds per acre. Like phosphorus, the sulfur content

generally decreases with depth, partly because part of the sulfur is organic, and organic matter decreases with depth, and also partly because organic sulfur is less subject to leaching than calcium sulfate (gypsum), the chief inorganic form found in soils.

The amount of sulfur available to crops is influenced not only by the soil supply, but also by that brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water, and consequently is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption, the amount of sulfur thus added to the soil is relatively large. At Urbana during the eight-year period, 1917 to 1924, there was added to the soil by the rainfall an average of 3.5 pounds of sulfur an acre a month. Similar observations have been made in other localities for shorter periods. The precipitation at the various points in the state in a single month has been found to vary from a minimum of three-fourths of a pound to more than ten pounds an acre.

These figures afford some idea of the amounts of sulfur added by rain, and also of the wide variations in amount under different conditions. Considering the amounts which are brought down in rainfall in addition to the soil supply, the facts would indicate that apparently there is little or no need for sulfur fertilizers in Coles county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started on a number of experiment fields in various parts of Illinois.

Potassium Content Relatively Uniform Thruout County

The potassium content of the soil exhibits less variation from type to type than any other element studied. The average amount in the surface soil is approximately 34,000 pounds per acre, and the entire range thru all the types in the county is from a minimum of 27,560 pounds up to 39,100 pounds per acre. The potassium concentration in the soil at different depths likewise shows very little variation.

Wide Variations in Calcium and Magnesium

Soils in general exhibit wide variations in their content of calcium and magnesium, and Coles county is no exception to this rule. In the surface soil, magnesium varies from 3,380 to 13,320 pounds per acre, while calcium varies from 5,000 to 18,900 pounds. Even the higher amount of total calcium noted does not indicate the presence of calcium carbonate (limestone) in the soil. Considerable amounts of calcium are always present, even in acid soils. Most of it is combined with silicic acid to form the complex silicate minerals and, while it serves to keep down the acidity, it may become available to plants so slowly as to make calcium deficiency a limiting factor in their growth. Added lime or limestone supplies readily available calcium in addition to correcting soil acidity.

The very high values for total calcium in the lower stratum of Black Clay Loam and Drab Clay Loam, namely, 118,060 and 73,910 pounds per acre, respectively, are to be attributed to the presence of calcium carbonate (limestone)

in this stratum. Leaching of native calcium carbonate proceeds downward with the result, in Coles county, that it has disappeared from the surface soil of practically the entire area, and has passed down below the 40-inch stratum sampled in the case of most types. Some increase in total magnesium accompanies the high calcium of these carbonate-containing strata. The increases are not great, however, because of the inability of magnesium to exist long in the soil in the form of carbonate. The carbonate of carbonate-containing soils is chiefly calcium carbonate.

In the upland soils variations in the amounts of calcium and magnesium at the different depths give some indication of the movement of these elements in soil formation. In the surface soil the calcium usually exceeds the magnesium in amount, as a result of the preponderance of calcium in the soil-forming materials. As these two bases are carried down in solution, magnesium is more readily absorbed than calcium in the soil mass, so that with increasing depth there is an increasing proportion of magnesium to calcium. This change is most pronounced in the most mature soils such as Light Gray Silt Loam On Tight Clay, where the ratios of magnesium to calcium in the upper, middle and lower strata are, respectively, .93, 1.13, and 2.29. That is, in the surface soil there is slightly less magnesium than calcium. In the second stratum there is slightly more, while in the lower stratum there is about 2⅓ times as much magnesium as calcium. On the other hand, in youthful soils where the leaching has been less intense or less prolonged, the ratio of magnesium to calcium shows little or no increase in the lower levels. For instance, in Black Clay Loam the ratios of magnesium to calcium are, in the three respective strata, .70, .79, and .51. Here the drop in *relative* amount of magnesium in the lower stratum is an expression of the calcium-carbonate accumulation noted above. Thus it will be seen that variations in the processes of soil development may be definitely reflected in the chemical properties of the soil itself.

Local Tests for Soil Acidity Often Required

It is impracticable to attempt to obtain an average quantitative measure of the calcium-carbonate content or the acidity of a given soil type because, while some samples will contain large amounts of calcium carbonate, others will contain none, but on the other hand will have a lime-requirement due to the soil acidity. We thus have what may be considered positive and negative values ranging, perhaps widely, on the opposite sides of the zero or neutral point. The numerical average of such values could have no significance whatever, since such an average would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types.

The qualitative field tests made in the process of the soil survey are much more numerous than the chemical analyses made in the laboratory, and do give a general idea of the predominating condition in the various types as to acidity or alkalinity. These tests, therefore, furnish the basis for some general recommendations which are given in the descriptions of individual types on pages 15

to 22. To have a sound basis for the application of limestone the owner or operator of a farm must usually determine individually the lime requirements of his different fields. The section in the Appendix dealing with the application of limestone (page 31) is pertinent and should be read in this connection.

Supplies of Different Elements Not Proportional to Crop Removal

In the foregoing discussion we have considered mainly the amounts of the plant-food elements in the surface 6⅔ inches of soil, and rather briefly the relative amounts in the two lower strata. We have noted that some of the elements of plant food exhibit no consistent change in amount with increasing depths. Other elements show more or less marked variation at the different levels, the trend of these variations serving in some cases as clues to the relative maturity of different soil types and the processes involved in their development.

By adding together the corresponding figures for all three strata, we have an approximate invoice of the total plant-food elements within the feeding range of most of our field crops, since the major portion of their feeding range is included in the upper 40 inches. One of the most striking facts brought out of this consideration of the data is the great variation within a given soil type in the relative abundance of the various elements present as compared to the amounts removed by crops. In one of the important types in the county, Brown Silt Loam, Upland, we find that the total quantity of nitrogen in all three strata is 14,730 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus is approximately one-third as much, or 4,850 pounds, but this amount is equivalent to the phosphorus in about twice as much corn. In the surface stratum, however, which is the zone of most intensive crop feeding, we find the relative amounts of nitrogen and phosphorus more nearly in accord with the rate of removal of these elements by crops. Here the nitrogen is equivalent to 4,700 bushels of corn, and the phosphorus to 6,000 bushels, or only one-third more than the nitrogen equivalent.

Other types show marked contrast to Brown Silt Loam with respect to total soil content in relation to rate of removal by crops. However, in most soils, except those which are peaty, phosphorus is more abundant than nitrogen when considered in terms of crop equivalents rather than absolute amounts of the respective elements.

Limitations of Chemical Analysis of the Soil Not Always Appreciated

The foregoing discussion should not be taken to mean that it is possible to predict how long any certain soil could be cropped under a given system before it would become exhausted. Nor do the figures alone indicate the immediate procedure to be followed in the improvement of a soil. It must be kept in mind that the *amount* of plant food shown to be present is not the sole measure of the ability of a soil to produce crops. The *rate* at which these elements are liberated from insoluble forms and converted to forms that can be used by growing plants is a matter of at least equal importance, as explained on page 29, and is not necessarily proportional to the total stocks present. One must know, therefore, how to cope with the peculiarities of a given soil type, if he is to secure the full

benefit from its stores of the plant-food elements. In addition, there are economic factors that must be taken into consideration, since it is necessary for one to decide at how high a level of productivity he can afford to maintain his soil.

The chemical soil analysis made in connection with the soil survey is seen to be of value chiefly in two ways. In the first place it reveals at once outstanding deficiencies or other chemical characteristics which alone would affect its productivity to a marked extent, or point the way to corrective measures. It should be borne in mind, however, that fairly wide departures from the usual

TABLE 2.—COLES COUNTY SOILS: PLANT-FOOD ELEMENTS IN UPPER SAMPLING STRATUM ABOUT 0 TO 6⅔ INCHES[1]

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
Upland Prairie Soils (300, 900, 1100)								
326, 926, 1126	Brown Silt Loam	54 200	4 700	1 030	660	35 120	7 920	9 690
320, 920, 1120	Black Clay Loam	75 520	7 220	1 840	1 260	32 490	13 320	18 900
1121	Drab Clay Loam	54 280	5 280	1 490	950	39 100	12 290	16 090
328, 928, 1128	Brown-Gray Silt Loam On Tight Clay	34 580	3 280	1 020	700	30 270	4 810	6 560
330	Gray Silt Loam On Tight Clay	22 710	2 640	750	320	33 490	4 830	5 510
Upland Timber Soils (300, 900, 1100)								
334, 934, 1134	Yellow-Gray Silt Loam	25 400	2 280	770	420	35 620	5 860	6 470
335, 935, 1135	Yellow Silt Loam	17 430	1 560	590	420	35 890	4 850	5 000
332, 1132	Light Gray Silt Loam On Tight Clay	20 180	2 080	840	400	35 080	6 320	6 820
364	Yellow-Gray Sandy Loam[2]							
Terrace Soils (1500)								
1526	Brown Silt Loam	39 500	3 840	940	600	27 560	7 020	11 500
1560	Brown Sandy Loam	39 040	3 960	980	620	37 320	4 800	10 480
1528	Brown-Gray Silt Loam On Tight Clay Over Gravel	19 740	2 100	1 060	540	31 940	3 380	5 060
1536	Yellow-Gray Silt Loam Over Gravel	25 010	2 460	1 000	480	34 550	3 780	6 620
1564	Yellow-Gray Sandy Loam	13 800	1 370	830	340	30 140	3 630	5 930
Bottom-Land Soils (1400)								
1454	Mixed Loam[3]							

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]Samples from neighboring counties were used in these averages.
[2]No samples were obtained for analysis.
[3]Analytical results are not included for Mixed Loam because of the heterogeneity of this type.

are necessary before the chemical analysis alone can be followed as a guide in practice without supplementary information from other sources. An example of the direct use of the results of chemical investigations is the marked shortage of potassium in peat soils associated with the need for potassium fertilizers; another example is the determination of the lime need of soils by chemical tests. It is quite probable that the results of chemical soil analyses are frequently misused by attempting to interpret small differences in the amount of a certain plant-food element as indicative of similar differences in the fertilizer need. For example, differences of 100 or 200 pounds of phosphorus per acre in soils containing 1,000 pounds or thereabout in the surface soil should not be considered as of any agricultural significance. Again, 100 pounds to the acre of active organic nitrogen added by plowing down a clover crop may be of more

TABLE 3.—COLES COUNTY SOILS: PLANT-FOOD ELEMENTS IN MIDDLE SAMPLING STRATUM, ABOUT 6⅔ TO 20 INCHES[1]

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300, 900, 1100)							
326, 926, 1126	Brown Silt Loam	69 510	6 280	1 660	1 130	70 750	18 950	17 700
320, 920, 1120	Black Clay Loam	70 750	6,810	2 630	1 500	67 860	27 750	34 920
1121	Drab Clay Loam	63 280	6 490	2 540	1 350	79 040	27 040	29 700
328, 928, 1128	Brown-Gray Silt Loam On Tight Clay	32 780	3 600	1 550	850	63 650	12 740	11 660
330	Gray Silt Loam On Tight Clay	18 920	2 510	1 200	240	61 430	15 450	12 480
	Upland Timber Soils (300, 900, 1100)							
334, 934, 1134	Yellow-Gray Silt Loam	19 530	2 300	1 310	510	75 190	20 640	12 850
335, 935, 1135	Yellow Silt Loam	15 480	1 750	1 250	600	75 390	20 550	8 550
332, 1132	Light Gray Silt Loam On Tight Clay	17 040	1 920	1 160	500	73 000	15 960	14 240
364	Yellow-Gray Sandy Loam[2]							
	Terrace Soils (1500)							
1526	Brown Silt Loam	33 600	3 480	1 840	600	79 360	12 680	20 960
1560	Brown Sandy Loam	33 360	3 480	1 520	480	71 880	10 080	16 640
1528	Brown-Gray Silt Loam On Tight Clay Over Gravel	15 160	2 080	2 040	680	66 760	11 960	9 960
1536	Yellow-Gray Silt Loam Over Gravel	17 880	2 520	2 000	420	77 640	10 000	12 280
1564	Yellow-Gray Sandy Loam	11 100	1 700	1 760	500	63 540	12 200	10 140
	Bottom-Land Soils (1400)							
1454	Mixed Loam[3]							

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Samples from adjoining counties were used in these averages.
[2]No samples were obtained for analysis.
[3]Analytical results are not included for Mixed Loam because of the heterogeneity of this type.

importance to the succeeding crop than a difference in soil composition of 1,000 pounds an acre of nitrogen.

Chemical Studies Important in Soil Investigations

The second function of soil analysis is as an aid in the scientific study of soils from many angles, the ultimate aim of which is, of course, the more economical utilization of the soil for efficient crop production. Not only do chemical studies aid in determining the processes involved in soil development under natural conditions, but also in determining the effects of different soil management and fertilizing practices upon the soil, and upon the utilization by crops of the plant-food elements involved.

TABLE 4.—COLES COUNTY SOILS: PLANT-FOOD ELEMENTS IN LOWER SAMPLING STRATUM, ABOUT 20 TO 40 INCHES[1]

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300, 900, 1100)							
326, 926, 1126	Brown Silt Loam	31 790	3 750	2 160	1 060	108 220	41 860	31 130
320, 920, 1120	Black Clay Loam	32 690	3 760	3 200	1 440	102 810	60 170	118 060
1121	Drab Clay Loam	36 890	4 260	3 080	1 340	114 260	57 720	73 910
328, 928, 1128	Brown-Gray Silt Loam On Tight Clay	27 350	3 200	2 430	740	99 280	32 420	31 880
330	Gray Silt Loam On Tight Clay	15 780	2 600	2 120	300	95 020	30 680	20 220
	Upland Timber Soils (300, 900, 1100)							
334, 934, 1134	Yellow-Gray Silt Loam	16 140	2 420	1 980	1 020	121 320	49 870	30 530
335, 935, 1135	Yellow Silt Loam	13 380	2 140	2 000	660	123 680	36 680	15 720
332, 1132	Light Gray Silt Loam On Tight Clay	22 620	2 820	1 920	800	109 560	42 600	18 600
364	Yellow-Gray Sandy Loam[2]	.....	.....	.....	.....	.....	.....	.....
	Terrace Soils (1500)							
1526	Brown Silt Loam	45 840	3 660	1 980	1 020	122 580	19 200	24 420
1560	Brown Sandy Loam	21 060	2 400	2 940	900	103 920	12 360	18 480
1528	Brown-Gray Silt Loam On Tight Clay Over Gravel	12 540	2 580	2 460	1 020	100 560	26 640	24 780
1536	Yellow-Gray Silt Loam Over Gravel	13 080	2 580	2 910	690	109 290	24 720	19 560
1564	Yellow-Gray Sandy Loam	10 170	1 980	2 310	600	88 830	20 460	17 220
	Bottom-Land Soils (1400)							
1454	Mixed Loam[3]	.....	.....	.....	.....	.....	.....	.....

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Some samples from neighboring counties were used in these averages.
[2]No samples were obtained for analysis.
[3]Analytical results are not included for Mixed Loam because of the heterogeneity of this type.

DESCRIPTION OF SOIL TYPES

The soil map of Coles county upon which this report is based was completed in 1921. Since that time there have been some changes in the mapping of soils. A soil map of the county made at this time would differ from the map completed in 1921, chiefly in showing a few more soil types. In the following description of each type will be found a brief discussion of any change which would be made in mapping it at the present time, and with these explanations the reader should get a better idea of the various soil types shown on the map.

UPLAND PRAIRIE SOILS

The upland prairie soils of Coles county occupy 313.27 square miles, or 61.57 percent of the area of the county.

The dark color of prairie soils is due to the accumulation of organic matter, derived very largely from the fibrous roots of prairie grasses that grew on this land for centuries. The stems and leaves of the grasses were in part burned by prairie fires or were lost in part thru decay, so that they actually added little organic matter to the soil; however, the protection afforded by this mat of constantly renewed, decaying material was of importance in retarding the decay of the roots. From a sample of virgin bluestem sod, one of the most common prairie grasses, it has been determined that an acre of this soil to a depth of 7 inches may contain as high as 13½ tons of roots.

Brown Silt Loam (326, 926, 1126)

About 42 percent, or over 200 square miles, of the area of Coles county is shown on the accompanying map as Brown Silt Loam. With advancing knowledge of soil classification, however, it is now possible to recognize within this area at least four and possibly five distinguishable soil types. Four of these will be described. The fifth occurs in portions of Piatt, Macon, Moultrie, and Coles counties, but has not as yet been studied sufficiently to justify considering it established. The four types now differentiated are Brown Silt Loam On Clay, Brown Silt Loam, Brown Silt Loam On Drift, and Light Brown Silt Loam On Drift. These types all occur on the areas shown on the map as Brown Silt Loam. Their occurrence bears a rather definite relation to topography, as will appear from the descriptions which follow.

Brown Silt Loam On Clay. This type occurs on nearly level areas. It was formed under conditions of intermittently poor drainage, which resulted in an accumulation of considerable fine-textured material in the subsoil. Associated with this fine texture and plasticity of the subsoil, or *B* horizon, is a gray color showing a lack of free air movement. The surface soil, or A_1 horizon, is dark brown in color and is in some places rather heavy for a silt loam. The subsurface or A_2 horizon is heavier than the A_1 and lighter in color.

Management.—This type, even tho it has a heavy subsoil, will underdrain satisfactorily. In tiling, the strings of tile should be placed closer together than for any of the other types mapped as Brown Silt Loam. Regular additions of fresh organic matter should be provided, for otherwise this soil will gradually be-

come more difficult to work. Limestone is needed for sweet clover or alfalfa, tho in light applications. The lowest portions of the type may need no limestone and occasionally small alkali spots occur. The harmful effects of the alkali may be corrected by applying 75 to 100 pounds of potash to the acre for corn. This type is similar to the soil on the Hartsburg and Aledo experiment fields. The results from these two fields are in agreement in indicating the value of manure on all the crops of the rotation; the value of residues, particularly for corn; and the failure of rock phosphate as used on these fields, particularly in the manure system, to cause sufficient increase in yields to justify advising its indiscriminate use on this soil type. If alfalfa is to be seeded, the application of 1,000 pounds of rock phosphate, or 500 pounds of superphosphate an acre would be advisable, or, if wheat is to be seeded to sweet clover, it would be advisable to make a trial application of either of these materials after plowing but before working down the wheat seed bed. The reader is referred to page 34 for a further discussion of the phosphate problem.

Brown Silt Loam. This type occurs on undulating topography. It has good surface drainage and underdrainage. The profile is friable and easily permeable to roots as well as to water. This type is not extensively developed in Coles county. Tho it is not strongly acid, a heavier application of limestone is needed than on the preceding type because it is more uniformly acid. The surface soil, or A_1 horizon, is brown in color and, unlike the preceding type, does not tend to be too heavy for a true silt loam. The subsurface, or A_2 horizon, is distinctly yellowish and is not much heavier than the A_1. The subsoil, or B horizon, is brownish yellow with some gray mottling present; it is a clay loam but is friable and only medium plastic.

Management.—This type is similar to the soil on the Kewanee experiment field. The results from this field (page 49) show a good response to manure alone and to residues and lime in combination. Where lime was used in addition to manure, an additional increase in yield was secured, but the increase was not so large as where lime was used in addition to residues. This behavior indicates that manure satisfies in part the same deficiency that lime satisfies on this medium-acid soil. The returns from the use of rock phosphate on this field are not such as to justify its unqualified recommendation. This is particularly true in the manure system. Where green manures were the source of nitrogen and organic matter, rock phosphate gave just about sufficient increase in yield to pay for its cost when used at the rate of one ton an acre once in the rotation. The Bloomington experiment field is located in part on this same type of soil. The results from this field (page 51) show excellent returns for phosphorus and lead to the recommendation that one of the phosphates be given a trial for wheat. The reader is referred to the discussion of these materials on page 34.

Brown Silt Loam On Drift. This type occurs on undulating to gently rolling topography and is found extensively developed thruout most of the county where dark-colored soils occur. The entire profile is similar in color to that of the last type described, but differs from it in character of the soil material,

particularly in having much more sand and gravel in the lower horizons. The surface soil, or A_1 horizon, to a depth of about 8 inches is brown in color and a silt loam in texture. It frequently contains a number of chert and other rock fragments. The A_2 horizon is a yellowish brown silt loam containing some rock fragments and extends to a depth of about 18 or 20 inches. The B horizon is a medium-mottled, dark yellow, sandy and gravelly clay, medium compact and slightly plastic. The C horizon is a yellow, sandy, gravelly clay loam, fairly friable, and not much compacted.

Management.—Brown Silt Loam On Drift is thought to be very similar in management requirements to Brown Silt Loam, the last type described. It differs in being slightly more acid, somewhat lower in organic matter, and more subject to erosion.

Light Brown Silt Loam On Drift. This type differs from Brown Silt Loam On Drift in being much lower in organic matter, more acid, and subject to serious erosion. The land is all tillable, but is spoken of by farmers as being a thin soil. This type occurs only on the more pronounced slopes of the two morainal ridges shown on the soil map, one extending as a broad belt across the southern part of the county and the other occurring as a small lobe north of Bushton. The surface, or A_1 horizon, is light brown or reddish brown in color and in places contains considerable glacial gravel. The subsurface, or A_2 horizon, is yellowish brown in color and contains more gravel than the surface. The subsoil, or B horizon, is gravelly glacial drift, somewhat compact but not plastic. The thickness of the various horizons varies because of differences in the rate of erosion on different areas. Carbonates commonly occur at a depth of 40 to 50 inches.

Management.—This type is less productive than any of those previously described. The soil needs frequent additions of fresh leguminous organic matter. It is more acid than less rolling land, and it must be handled carefully if erosion is to be reduced below the point where it is very harmful. The trial of either rock phosphate or superphosphate for wheat which is to be seeded to clover is advised for this soil.

Black Clay Loam (320, 920, 1120)

Over 87 square miles of Black Clay Loam are mapped as such in Coles county. However, this Black Clay Loam as mapped is now recognized to include four distinguishable types. These four types will not be described as they do not differ in topography so strikingly as do the separations noted for Brown Silt Loam and are therefore less easily recognized. For this reason the following generalized description of the type as it is mapped will be given instead of each type as now differentiated.

The A_1 horizon is 10 to 12 inches deep, and is a dark brown to black clay loam. The A_2 horizon usually extends to a depth of about 20 inches, is drabbish black in color, and is somewhat heavier than the A_1 horizon. It usually contains small yellow spots and in the lighter portions of the type is distinctly yellow

instead of drabbish black. The *B* horizon in the heavier portions of the type is a gray or heavily mottled, compact, and plastic clay, while in the lighter portions it is a strongly mottled yellow, compact, medium-plastic clay or clay loam.

Management.—It should be noted that alkali spots occur in Black Clay Loam and that potash treatment is needed on some of them because of the high concentration of soluble salts. Lime is generally not needed on this soil but regular additions of fresh organic matter should be provided for as an aid in maintaining a good physical condition. The use of phosphate is not likely to prove profitable on this soil as is indicated by the results from the Minonk and Hartsburg experiment fields. If no manure is available it might be well to try rock phosphate at the rate of about 1,000 pounds an acre, or superphosphate at the rate of about 250 pounds an acre, for wheat. The summarized results from the Minonk and Hartsburg fields are given on pages 55 and 56.

Drab Clay Loam (1121)

Drab Clay Loam is a minor type in Coles county, occurring only in two areas in the north-central part of the county. It is a soil formed under poor drainage conditions. The reason for its drab color instead of black is not entirely clear but seems to be associated with a set of conditions which limited the growth of the grasses.

The surface, or A_1 horizon, is about 7 inches thick and is usually a drabbish black clay loam or silty clay loam. The subsurface, or A_2 horizon, is somewhat lighter in color than the surface, usually being drabbish brown. The subsoil, or *B* horizon, is drab or yellowish drab containing reddish brown spots. It is heavy but will underdrain.

Management.—Drab Clay Loam is usually not acid and in places is alkaline. It is relatively low in organic matter. It also requires thoro underdrainage. Much has been done by the construction of dredge ditches and the laying of tile to take care of the excess water on this soil. Alkali spots are common and lime concretions and marly material are often found within forty inches of the surface.

Brown-Gray Silt Loam On Tight Clay (328, 928, 1128)

Brown-Gray Silt Loam On Tight Clay occurs chiefly in the southeast and southwest corners of the county and south and east of Ashmore. The total area occupied by this type is only about 8 square miles. This type is characterized by a grayish brown surface, or A_1 horizon, a gray subsurface, or A_2 horizon, and a brown, highly plastic, and compact subsoil, or *B* horizon. The *B* horizon is mottled with yellow, reddish brown, and gray.

Management.—The feature of Brown-Gray Silt Loam On Tight Clay which is of most importance from the standpoint of soil management is the impervious *B* horizon which occurs at a depth varying from about 16 to 28 inches. Underdrainage is not effective in removing excess water, because water passes thru the plastic material too slowly. Furrows and open ditches must be depended on for drainage. Crops are more subject to injury from drouth on this soil than on one in which the movement of water and penetration of roots are good. This

soil is acid. Following the application of limestone, good sweet clover crops may be grown, and this in turn makes it possible to grow satisfactory corn crops except in seasons when the rainfall is not well distributed. This soil type is probably better suited to small grains, soybeans, cowpeas, and clover than to corn.

Gray Silt Loam On Tight Clay (330)

Gray Silt Loam On Tight Clay is a minor type in Coles county, occupying a total area of less than two square miles. It is found just south of the moraine in the southwest and southeast corners of the county. This type is similar in some respects to Brown-Gray Silt Loam On Tight Clay, but is a poorer soil. The surface, or A_1 horizon, is about 7 inches deep and is gray in color. The subsurface, or A_2 horizon, is light gray in color. This stratum is friable and is easily penetrated by water and roots but has a low water-holding capacity. The subsoil, or B horizon, is heavy and plastic and highly impervious to roots and to water. It lies at a depth of about 18 inches, and is usually from 8 to 12 inches in thickness. Below this impervious layer, a fairly friable material occurs.

Management.—Gray Silt Loam On Tight Clay is strongly acid and no improvement in its productivity can be expected until limestone has been applied and nitrogen and fresh organic matter provided thru manure or thru the growing of legumes, preferably sweet clover. Drainage must be taken care of by open ditches and furrows since the impervious subsoil makes the use of tile impossible.

UPLAND TIMBER SOILS

Nearly one-third of the area of Coles county is occupied by light-colored or timber soils. These soils are usually characterized by a yellow or yellowish gray color, which is due to the low organic-matter content. This lack of organic matter has been caused by the long-continued growth of forest trees. As the forests invaded the prairies, the following effects were produced: the shading of the trees prevented the growth of grasses, the roots of which are mainly responsible for the large amount of organic matter in the prairie soils; and the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed or were destroyed by forest fires.

The timbered soils are of two kinds, the undulating and the eroded.

Yellow-Gray Silt Loam (334, 934, 1134)

Yellow-Gray Silt Loam, covering about 134 square miles as mapped in Coles county, includes in reality several light-colored soil types. The flat, nearly level areas have a relatively impervious, gray subsoil, while the better-drained areas have a sufficiently open subsoil for good underdrainage and the color is yellowish, or even reddish if the slope is strong. A detailed profile description for Yellow-Gray Silt Loam as mapped in this county cannot be written since, as above stated, several types are included under this name.

Management.—The nearly level portions of this type are more acid than the undulating and rolling portions and are naturally poorly drained. Lime is a

general requirement, tho the amount needed varies not only with the constitutional requirements of the soil but also with other factors, as for example, with the length of time and intensity with which a field has been farmed. Leguminous organic matter is also a general requirement and provision should be made for the regular growth of clover, preferably sweet clover, on any of this type which is farmed. Phosphate should give profitable returns on the undulating portions of this type, particularly if used for wheat. Either rock phosphate or superphosphate may be tried, the former at the rate of about 1,000 pounds an acre and the latter at the rate of about 250 pounds.

Yellow Silt Loam (335, 935, 1135)

Yellow Silt Loam occurs in Coles county along Embarrass river and its tributaries. Some areas are found along streams in other portions of the county, but they are small in extent. The total area of this type in Coles county aggregates about 29 square miles. A large percentage of the type is suitable only for pasture, timber, or orchard because of its steep topography. The areas along the Little Embarrass in Township 14 North, Range 14 West, are not sufficiently steep to prevent their use for general farming. The character of the soil occupying these slopes varies greatly depending on local variations in the material from which the soil is formed and on the rapidity of erosion.

Light Gray Silt Loam On Tight Clay (332, 1132)

Light Gray Silt Loam On Tight Clay occupies a total of only 122 acres in Coles county. It is a very poor soil and it is probably unwise at the present time to undertake its improvement. Further information regarding this soil may be had by correspondence.

Yellow-Gray Sandy Loam (364)

Yellow-Gray Sandy Loam occupies a total area of about one square mile in Coles county and is found along the Little Wabash in the southwestern part of the county. This soil was formed from material carried down from the moraine at the north by the Little Wabash and deposited in its present location by the wind. It is dune-like in topography and varies somewhat in its characteristics because of the assorting action of the wind.

The surface, or A_1 horizon, is gray in color. It varies in depth but is usually not shallower than 5 inches nor deeper than 7 inches. The subsurface, or A_2 horizon, is light gray, and the subsoil, or B horizon, is drabbish gray and is medium compact but friable. The sand content of this soil is not so high as is common for the type except on the ridges.

Management.—Yellow-Gray Sandy Loam is acid and is deficient in nitrogen and organic matter. Each field which is to be improved should be tested in detail for acidity and then sufficient limestone applied so that sweet clover may be grown. If sweet clover is given a regular place in the rotation and used primarily as a soil-improving crop, this soil should produce satisfactory yields.

TERRACE SOILS

Relatively small areas of terrace soils occur in Coles county. The terraces were built up, for the most part, during and immediately following the Glacial period when overloaded and flooded streams deposited an immense amount of material in their channels. Later as the streams diminished in size or cut their channels deeper, new bottoms were developed, leaving the old flood plains above overflow, thus forming terraces. It was upon these plains that the terrace soils developed.

Brown Silt Loam (1526)

Brown Silt Loam, Terrace, occurs as small areas along the lower course of Embarrass river and totals slightly more than one square mile. It differs, so far as is known, in no important particular from Brown Silt Loam, Upland. The reader is referred to the discussion of the latter type for suggestions regarding the management of this soil (page 16).

Brown Sandy Loam (1560)

Brown Sandy Loam occurs on terraces in a few small areas along Embarrass river. It has a total area in Coles county of only about one hundred acres. Information regarding this soil and suggestions for its management may be had by writing to the Agricultural Experiment Station.

Brown-Gray Silt Loam On Tight Clay Over Gravel (1528)

The terrace type Brown-Gray Silt Loam On Tight Clay Over Gravel differs in no essential from the corresponding upland type, Brown-Gray Silt Loam On Tight Clay, in this corner of the county except that it is underlain at a depth of 5 to 6 feet by a stratum of gravel. This gravel stratum might afford an outlet for vertical drainage.

Yellow-Gray Silt Loam Over Gravel (1536)

Yellow-Gray Silt Loam Over Gravel is the most extensive terrace type in Coles county. It occupies a total area of about 3½ square miles but occurs only in small areas and is found along both the Kaskaskia and Embarrass rivers. It does not differ materially from the well-drained Yellow-Gray Silt Loam, Upland. The reader is referred to this latter type (page 19) for the description of this terrace soil and suggestions for its management.

Yellow-Gray Sandy Loam (1564)

Yellow-Gray Sandy Loam, Terrace, occupies a total area of only 45 acres in Coles county. It differs from Yellow-Gray Sandy Loam, Upland, in method of formation but not in soil character. The reader is asked to refer to the discussion of the upland type (364) for suggestions regarding the management of this terrace type.

BOTTOM-LAND SOILS

Bottom-land soils, as the name implies, are those found along the stream bottoms. In Coles county, only one type is included in this group.

Mixed Loam (1454)

Mixed Loam as it occurs in Coles county is good agricultural land and is, in large part, cropped. Corn is not generally grown because of overflow. Mixed Loam varies in texture and in other soil characters because of local differences in the velocity of the running water in which the sediment making up the soil was deposited.

Management.—The diversity of Mixed Loam calls for different tillage methods. In places where the soil is heavy, care must be used not to puddle the soil. The soil is not acid because of frequent overflow, and needs only good tillage to produce good corn crops.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items, such as native vegetation (whether timber or prairie), topography, and geological origin and formation, may assist in the differentiation of types, altho they are not fundamental to it.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. In describing a matured soil, three horizons designated as *A*, *B*, and *C* are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the *A* horizon.

C designates the layer lying below the *B* horizon and in which the material has been less affected by the weathering processes.

Frequently differences within a stratum or zone are discernible, in which case it is subdivided and described under such designations as A_1 and A_2, B_1 and B_2.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in differentiating soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made wherever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of this report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their respective index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoian moraines,* including the moraines of the Illinoian glaciations
300 *Lower Illinoian glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoian glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoian glaciation,* covering about fourteen counties northwest of the middle Illinoian glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoian
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation

1000 *Late Wisconsin moraines*, including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation*, covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation*, lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands*, formed by material derived from the Illinoian or older glaciations
1400 *Late river-bottom and swamp lands*, formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces*, bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits*, formed by Lake Chicago, the enlarged glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the remainder of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoian glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to the last of November. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction.

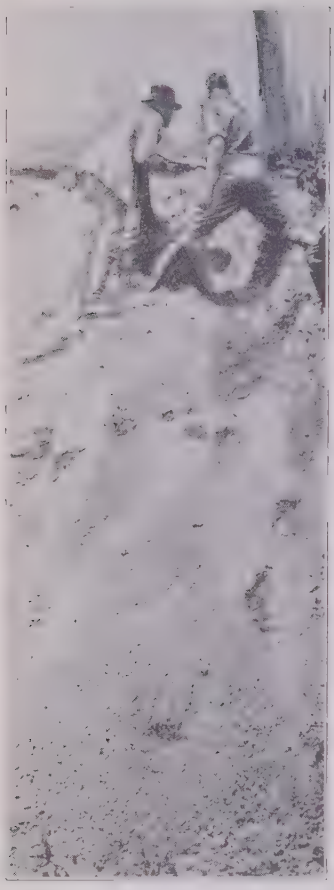


FIG. 5.—EXAMINING THE SOIL PROFILE

Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development in road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 6.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil

management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

At least ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed

FIG. 6.—ALL ESSENTIAL PLANT-FOOD ELEMENTS MUST BE PRESENT

The jars in which these corn plants are growing contain pure sand to which have been added various combinations of the essential plant-food elements. If a single one of these elements is omitted, the plants cannot develop; they die after the small supply stored in the seed becomes exhausted.

from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants are dependent upon the soil for the other elements, and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5.
[2]Young second-year growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering

bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4 have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

The nitrogen problem is one of foremost importance in American agriculture. There are four reasons for this: nitrogen is becoming increasingly deficient in most soils; its cost when purchased on the open market is often prohibitive; it is removed from the soil in large amounts by crops; and it is readily lost from soils by leaching. A 50-bushel crop of corn requires about 75 pounds of nitrogen for its growth; and the loss of nitrogen from soils by leaching may vary from a few pounds to over one hundred pounds an acre in a year, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about 69 million pounds of atmospheric nitrogen. Leguminous plants such as clover are able, with the aid of certain bacteria, to draw upon the inexhaustible supply of air nitrogen, utilizing it in their food requirements. In so doing these leguminous plants, thru the decay of their own

FIG. 7.—LEGUMES CAN OBTAIN THEIR NITROGEN FROM THE AIR

The photograph tells the story of how clover benefits the soil. In the pot at the left all the essential plant-food elements, including nitrogen, are supplied. In the middle jar all the elements, with the single exception of nitrogen, are present. At the right nitrogen is likewise withheld but the proper bacteria are supplied which enable the clover to secure nitrogen from the air.

tissues, add to the soil nitrogen that has been taken from the air and transformed into food material that can be assimilated by other kinds of crops that follow.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named.

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

Different soil types display great variation in phosphorus content. In Illinois soils a range from 320 to 4,900 pounds an acre has been found in the surface 6⅔ inches, depending mainly on the origin of the soil.

The removal of phosphorus by continuous cropping slowly reduces the amount of this element available for crop use unless its addition is provided for by natural means such as overflow, or by agricultural practices such as the addition of phosphatic fertilizers and the use of rotations in which deep-rooting leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different phosphorus-containing materials that are used as fertilizers. The more important of these are rock phosphate, superphosphate, bone meal, and basic slag.

Rock Phosphate.—Rock phosphate is a mineral substance found in vast deposits in certain regions. A good grade of the rock should contain 12 to 15 percent of the phosphorus element. The rock should be ground to a powder fine enough to pass thru a 100-mesh sieve, or even finer.

Superphosphate.—Superphosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. By further processing, different concentrations are produced. The most common grades of superphosphate now on the market contain respectively 7, 8¾, and 10½ percent of the element phosphorus, and even more highly concentrated products containing as high as 21 percent are to be had. In fertilizer literature the term phosphorus is usually expressed as "phosphoric acid" (P_2O_5) rather than the element phosphorus (P), and the chemical relation between the two is such as to make the above figures correspond respectively to 16, 20, 24, and 48 percent of phosphoric acid. Besides phosphorus, superphosphate also contains sulfur, which is likewise an element of plant food. In general, phosphorus in superphosphate is considered to be more readily available for absorption by plants than that of raw rock phosphate.

Bone Meal.—Prepared from the bones of animals, bone meal appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen. If the material is purchased only for the sake of the phosphorus, the cost of the nitrogen represents a useless expense. Steamed bone meal is prepared by extracting most of

the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate, containing about 10 to 12 percent of the element phosphorus and about 1 percent of the element nitrogen.

Basic Slag.—Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore tends to influence the soil reaction in the direction of reducing soil acidity.

Comparative Value of Different Forms of Phosphorus.—Obviously the carrier of phosphorus that gives the most economical returns, considered from all standpoints, is the best one to use. Altho this matter has been the subject of much discussion and investigation, the question remains unsettled. The fact probably is that there is no single carrier that will prove the most economical under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

The relative cheapness of raw rock phosphate as compared with the treated material, superphosphate, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in the form of rock than in the form of superphosphate, the ratio being, under present market conditions, roughly speaking 3½ to 1: that is to say, a dollar will purchase about three and a half times as much of the phosphorus element in the form of rock phosphate as in the form of superphosphate, and this is an important consideration if one is interested in building up a phosphorus reserve in the soil.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using superphosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, the silt loams and clay loams, are well stocked with potassium, altho it exists mainly in a very slowly soluble form. Many field experiments in various sections of Illinois during the past twenty-five years have shown little or no response to the application of potassium in the production of our common grain and hay crops. On the light-colored soils of southern Illinois, however, where stable manure has not been employed, potassium has been applied, with profit, the benefit appearing mainly in the corn crop.

Peat soils are usually low in potassium content. It has frequently been demonstrated in field experiments located on peat land that the difference between success and failure in raising crops depends upon the application of a potash fertilizer.

Potassium has proved beneficial also on the so-called "alkali" spots occurring on certain soil types that are rather high in organic matter, including peat and very dark-colored sandy, silt, and clay loams. The potassium salts in this case appear to exert a corrective influence over what seems to be an unbalanced plant-food condition caused by an excess of nitrate in the soil.

Potassium fertilizer may be procured in the form of one of its salts, such as chlorid, sulfate, or carbonate of potassium, and any of these materials may be applied, where needed, at the rate of 50 to 150 pounds an acre, according to the method of distribution. For our most common crops about the only basis for choosing among these forms is the matter of price, taking into consideration the potassium content. Kainit is another substance containing potassium, but it is combined with magnesium in the form of a double salt. It is therefore less concentrated than the salts mentioned, and so should be applied in larger quantities. An application of about 200 pounds or more of kainit to the acre is suggested.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic

matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and cornstalks should be turned under, and not burned. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If trampled too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the corn is planted. Whether the crop be corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices of produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the best adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)
Sixth year —Clover, or clover and grass

In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed; or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

The two following rotations are suggested as especially adapted for combating the corn borer:

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Corn (for silage)
Sixth year —Wheat (with sweet clover)

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Wheat (with alfalfa)
Sixth Year —Alfalfa

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)
Fifth year —Clover

First year —Corn
Second year —Soybeans
Third Year —Corn
Fourth year —Wheat (with legume)
Fifth year —Legume

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field rotating over all fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or Soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute barley or rye for the wheat or oats. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover, or it may include alfalfa used as a biennial. The mixing of alfalfa with clover seed for a legume crop is a recommendable practice. In connection with livestock production it may be desirable to mix grass with the clover for pasture or hay. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to Those Occurring in Coles County)

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various soil types. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on soil types described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to forty acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with each crop represented every year.

Farming Systems

On most of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system but certain modifications have been introduced in recent years, as explained in the descriptions of the respective fields.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots at the beginning was usually standardized according to a rather definite system. With advancing experience, however, new problems arose calling for new experiments, so that on most of the fields plots have been divided and a portion given over to new systems of treatment, at the same time maintaining the original system essentially unchanged from the beginning.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—Limestone has usually been applied at the rate of 4 tons an acre as an initial application, and 2 tons an acre every four years thereafter until a considerable excess has accumulated in the soil. Rock phosphate has been applied at the rate of one ton an acre at the beginning, followed by an annual acre-rate of 500 pounds applied once in the rotation until a considerable excess has accumulated. Potassium has been applied usually in the form of 200 pounds of kainit a year. When kainit was not available, owing to conditions brought on by the World War, potassium carbonate was used.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated. (sP = superphosphate, bP = bone meal, rP = rock phosphate, slP = slag phosphate)
K = Potassium (usually in the form of kainit)
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed

THE ALEDO FIELD

An experiment field representing the soil type Brown Silt Loam On Clay is located in Mercer county just west of Aledo. This field has been in operation since 1910. From its physical aspects this field should be well adapted to experimental work, the land being unusually uniform in topography and in soil profile.

There are two general systems of plots and they are designated as the major and the minor systems. The major system comprizes four series made up of 10 plots each. The plots were handled substantially as described for standard treatment until 1918, when it was planned to harvest the first crop of

red clover on the residues plots for hay and to plow down the second crop if no seed were formed. In 1921 the return of the oat straw was discontinued. In 1923 the rotation was changed to one of corn, corn, oats and wheat. In this rotation it was planned to seed hubam clover in the oats on all plots, for use as hay or for soil improvement, and common sweet clover in the wheat on the residues plots for use as a green manure. Since this change, no residues except cornstalks and the green manure have been returned to the residues plots. The limestone applications were temporarily abandoned in 1923 after the different series had received 7½ to 9 tons an acre and no more will be applied until a need for lime appears. The phosphate applications were evened up to a total of 4 tons an acre in 1924, and no more will be applied for some time at least.

A summary of the results, showing the average annual yields obtained for the period beginning when complete soil treatment came into sway is given in Table 7. Comparisons in terms of crop increases, intended to indicate the effect of the different fertilizing materials applied is shown in the lower section of the table.

In looking over these results, one may observe first the beneficial effect of animal manure on all crops but especially on corn. This suggests the advisability of carefully conserving and regularly applying all stable manure. Resi-

TABLE 7.—ALEDO FIELD: SUMMARY OF CROP YIELDS

Average Annual Crop Yields 1912-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Corn	Oats	Clover	Soybeans[1]	Stubble Clover	
							Sweet clover	Hubam[2]
		14 crops	*23 crops*	*16 crops*	*6 crops*	*3 crops*	*2 crops*	*2 crops*
1	0	29.9	56.0	58.6	(2.21)	(1.60)	.....	.....
2	M	35.1	69.9	65.7	(2.74)	(1.63)	.....	.....
3	ML	35.5	73.5	68.5	(3.12)	(1.60)	.....	(1.12)
4	MLP	37.2	74.7	69.5	(3.05)	(1.61)	.....	(1.20)
5	0	31.0	58.0	60.0	(2.00)	(1.61)	.....	.....
6	R	31.8	64.5	61.5	(1.91)	(1.65)	.....	.....
7	RL	34.2	71.7	66.8	(1.79)	(1.88)	(1.57)	(.52)
8	RLP	37.9	74.1	68.3	(2.08)	(2.03)	(1.66)	(.80)
9	RLPK	37.8	75.4	70.7	(1.73)	(2.09)	(1.99)	(.57)
10	0	30.2	56.3	58.8	(2.38)	(1.62)	.....	.....
	Crop Increases							
	M over 0	5.2	13.9	7.1	(.53)	(.03)	.....	.....
	R over 0	.8	6.5	1.5	−(.09)	(.04)	.....	.....
	ML over M	.4	3.6	2.8	(.38)	−(.03)	.....	(1.12)
	RL over R	2.4	7.2	5.3	−(.12)	(.23)	(1.57)	(.52)
	MLP over ML	1.7	1.2	1.0	−(.07)	(.01)	.....	(.08)
	RLP over RL	3.7	2.4	1.5	(.29)	(.15)	(.09)	(.28)
	RLPK over RLP	− .1	1.3	2.4	−(.35)	(.06)	(.33)	−(.23)

[1]Soybeans all evaluated as hay, altho some plots were harvested as seed.

[2]Two crops hubam on Plots 3 and 4 but only 1 crop on 7, 8 and 9.

dues alone have been beneficial for the second year corn but have shown little effect on the other crops of the rotation.

Where limestone has been applied, there is usually some increase in average yields, sufficient, at least, to cover the cost of the limestone.

The addition of rock phosphate to the treatment has had very little effect in the manure system. Somewhat more favorable are the results in the residues system, but under present market conditions, the cost of rock phosphate applied in the manner of these experiments exceeds the value of the crop increase. However, the economic story has not all been told, for the application of lime and phosphate has been discontinued in order to observe the residual effects. The results of the next few years, therefore, will be awaited with great interest.

For the effect of potassium treatment Plots 8 and 9 should be compared. No significant response appears from this treatment so far as these common field crops show.

Special Phosphate Experiments

The so-called minor system of plots on the Aledo field is given over to a comparison of the effectiveness of different carriers of phosphorus.

In this experiment each series contains four plots. Plot 1 receives residues treatment only; Plot 2 receives residues and phosphorus in one of the forms under test; Plot 3 receives residues, limestone, and phosphorus; and Plot 4 is similar to Plot 3 with phosphorus omitted. On one series steamed bone meal is used as the carrier of phosphorus and is applied at the rate of 200 pounds per acre per year. On another series superphosphate is applied at the yearly rate of 333⅓ pounds per acre. On a third series rock phosphate serves as the source of phosphorus and is applied at the rate of 666⅔ pounds per acre per year. On the last series basic slag phosphate is applied at the rate of 250 pounds per acre per year.

The yields for all crops harvested on these plots are recorded in Table 8. Table 9, which is derived from Table 8, shows the value of the increase in crop yield presumed to have resulted from applying the various forms of phosphatic fertilizers for the 13 crops harvested since the beginning of the applications up to 1928. In computing these comparisons, each phosphate plot is compared with its neighboring non-phosphate plot. Aside from the soybeans, the figures show without exception more or less crop increase on the phosphorus plots, no matter what the form of carrier employed.

The difficulty in arriving at a general conclusion regarding the comparative economy in the use of these different phosphorus materials is obvious, for all depends upon their relative cost, which fluctuates from time to time. Furthermore, the prices received from farm produce likewise fluctuate; and to complicate matters still further, these fluctuations do not necessarily run parallel with those of the fertilizer cost. However, one may compute for himself the relative economy of producing these crop increases by applying any set of prices for crops and fertilizers which appear to be most applicable according to prevailing market conditions. For the purpose of furnishing an illustration of such a computation, the December 1 market quotations for the years in which the

TABLE 8.—ALEDO FIELD: PHOSPHATE EXPERIMENT

Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1916[1] Corn	1917[1] Oats	1918[1] Soy-beans	1919 Wheat	1920 Corn	1921 Oats	1922 Clover hay	1923 Corn	1924 Corn	1925 Oats	1926 Wheat	1927 Corn	1928 Corn
501	R.....	53.4	85.5	18.9	32.4	72.8	48.9	(2.88)	83.5	58.2	63.9	44.0	33.9	69.8
502	RbP.....	61.7	91.7	19.0	34.7	86.4	61.9	(3.25)	82.7	66.0	75.0	59.2	63.2	71.7
503	RLbP.....	61.5	90.6	23.2	35.6	87.3	53.3	(3.48)	82.5	66.8	73.4	62.0	71.3	78.3
504	RL.....	55.1	80.5	22.6	32.9	77.7	47.7	(2.61)	88.2	60.3	64.5	44.6	58.5	72.0
601	R.....	55.2	84.7	19.5	33.0	71.2	53.6	(3.17)	84.7	57.3	64.4	43.3	37.2	71.3
602	RsP.....	57.8	87.7	18.7	38.3	87.1	60.9	(3.23)	82.5	65.9	76.1	60.6	54.8	73.2
603	RLsP.....	64.7	83.4	23.1	38.2	88.1	52.3	(3.53)	77.6	64.7	78.1	64.4	67.0	74.9
604	RL.....	51.9	81.7	24.6	32.8	84.9	50.2	(3.06)	84.1	51.9	64.1	47.3	60.8	74.4
701	R.....	54.3	83.1	20.8	34.2	75.6	52.8	(3.41)	82.8	61.2	66.6	44.8	39.9	72.3
702	RrP.....	58.8	83.3	23.3	36.7	80.4	63.0	(3.60)	87.8	69.3	70.3	59.2	61.8	74.3
703	RLrP.....	57.2	81.2	28.1	36.7	80.2	53.3	(3.82)	86.6	70.8	67.8	57.5	67.8	76.5
704	RL.....	52.1	81.7	26.9	34.1	82.0	48.9	(3.15)	84.6	62.5	66.3	48.8	63.0	74.6
801	R.....	57.6	73.8	18.0	33.7	68.1	54.8	(2.62)	74.3	58.8	45.0	45.8	42.2	70.4
802	RslP.....	56.4	87.8	20.6	38.1	81.0	66.2	(3.66)	80.0	69.1	66.3	60.2	60.7	69.3
803	RLslP.....	53.3	78.9	23.7	38.4	83.6	57.0	(3.63)	82.0	70.2	66.7	66.0	73.1	71.0
804	RL.....	51.8	77.5	21.8	33.3	70.4	59.8	(2.99)	82.6	59.9	53.9	48.2	60.4	75.1

[1]No residues.

respective crops were actually produced have been applied to the results of these Aledo plots. The value of soybeans is arbitrarily set at $1.50 a bushel. For the cost of fertilizer materials the prices of phosphates are estimated as follows: bone meal, $40 a ton; superphosphate, $24; rock phosphate, $12; and slag phosphate, $20 a ton.

TABLE 9.—ALEDO FIELD: PHOSPHATE EXPERIMENTS

Value of Crop Increases Produced by the Various Forms of Phosphate, Computed from Yields in Table 8

Comparison of treatments	Wheat *2 crops*	Corn *6 crops*	Oats *3 crops*	Clover *1 crop*	Soy-beans *1 crop*	Total increase *13 crops*	Cost of phos-phate *13 years*	Profit from *13 crops*	Profit per acre per year
Bone meal, residues, *over* residues	$23.35	$44.04	$11.67	$ 4.63	$ .15	$83.83	$52.00	$31.83	$ 2.45
Bone meal, residues, lime *over* residues, lime	26.90	27.01	11.31	10.88	.90	77.00	52.00	25.00	1.92
Superphosphate, residues, *over* residues	32.23	32.12	8.15	.75	−1.20	72.05	52.00	20.05	1.54
Superphosphate, residues, lime, *over* residues, lime	32.20	25.33	6.62	5.88	−2.25	67.77	52.00	15.77	1.21
Rock phosphate, residues, *over* residues	22.81	34.51	4.38	2.38	3.75	67.83	52.00	15.83	1.22
Rock phosphate, residues, lime, *over* residues, lime	16.07	17.15	1.49	8.38	1.80	44.89	52.00	− 7.11	− .55
Slag phosphate, residues, *over* residues	26.80	32.46	19.86	13.00	3.90	96.02	32.50	63.52	4.89
Slag phosphate, residues, lime, *over* residues, lime	32.43	24.59	11.07	8.00	2.85	78.94	32.50	46.44	3.57

Reckoned on the basis of the above prices, it appears from the last column of Table 9 that slag phosphate has produced the most profitable returns of the four phosphorus carriers in the test, bringing an average profit of $4.89 an acre yearly where applied without limestone and $3.57 where applied with limestone. Bone meal has given an average profit of $2.45 applied without limestone and $1.92 applied with limestone. Superphosphate has returned $1.54 used without limestone and $1.21 used with limestone. Rock phosphate has produced a profit of $1.22 an acre a year when applied without limestone and a loss of 55 cents when used with limestone.

In considering these results, it may be pointed out that the quantities of phosphatic materials employed in these experiments are, with the possible exception of the slag phosphate, greater than ordinarily would be used, or need to be used, in good farm practice. Moreover, no consideration is given in these comparisons to the relative phosphorus reserves which should have accumulated in the soil. Finally, it should be emphasized that the order of these values might be easily shifted by a relatively small change in commodity prices.

Limestone at the rate of 4 tons an acre was applied to Plots 3 and 4 in 1912 when the land was still under alfalfa, and another dressing was added in 1917 after the present experiments were under way. The results from the limestone treatment are shown in Table 10.

At the prices for produce and limestone assumed in these computations, a profit of $1.69 an acre a year for limestone applied without phosphate of any kind is found. Where limestone was applied with bone meal, the limestone profit was 99 cents an acre a year, and with superphosphate it was likewise 99 cents an acre. Used with rock phosphate, the crop increases were so small that there

TABLE 10.—ALEDO FIELD: PHOSPHATE EXPERIMENTS

Value of Crop Increases Produced by Limestone, Computed from Yields in Table 8

Comparison of treatments	Wheat *2 crops*	Corn *6 crops*	Oats *3 crops*	Clover *1 crop*	Soy-beans *1 crop*	Total increase *13 crops*	Cost of lime-stone[1] *13 years*	Profit from *13 crops*	Profit per acre per year
Limestone, residues, *over* residues	$ 3.25	$22.14	$−.40	$−.84	$ 7.01	$31.16	$ 9.18	$21.98	$ 1.69
Limestone, residues, bone meal, *over* residues, bone meal	5.31	11.35	−3.76	2.88	6.30	22.08	9.18	12.90	.99
Limestone, residues, super-phosphate, *over* residues, superphosphate	4.43	11.93	−4.58	3.75	6.60	22.02	9.18	12.84	.99
Limestone, residues, rock phosphate, *over* residues, rock phosphate	−2.07	5.00	−5.04	2.75	7.20	7.84	9.18	−1.34	− .10
Limestone, residues, slag phosphate, *over* residues, slag phosphate	7.71	11.26	−1.81	− .38	4.65	21.44	9.18	12.26	.94

[1]Owing to the fact that the first application of limestone on these plots was made for alfalfa four years before the present experiments were started, the total expense of $12 an acre for limestone is prorated, leaving a charge of $9.18 for the 13 crops involved in the present experiments.

was a loss of 10 cents an acre a year. Applied with slag phosphate, the returns show a profit of 94 cents an acre a year.

It appears, therefore, that by distributing the cost of the limestone over the years since its first application, this material has returned a moderate profit except where used with rock phosphate.

It should be observed that the Aledo field represents one of those borderline cases, so to speak, in which the upper soil is nearly neutral or only slightly acid and the lime requirement, therefore is not very marked. As time goes on, however, and cropping continues, a greater need for lime will probably develop. By discontinuing liming on these plots the annual cost of the limestone already applied is automatically reduced, so that net returns which hitherto have perhaps represented an actual loss may sooner or later result in a positive profit.

THE MORROW PLOTS

As representing the soil type Brown Silt Loam, the field experiments on the Morrow Plots, which have been continued for more than half a century, will be of special interest.

The Morrow Plots are located on the campus of the University of Illinois. This series now consists of three plots divided into halves, and the halves are subdivided into quarters. On one plot, corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904. Besides farm manure, phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. In 1925 the phosphates were evened up to a total of 3,300 pounds of bone meal and 13,200 pounds of rock phosphate and their application discontinued. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre. From 1903 until 1920, legumes were seeded in the corn on the south half of each plot. Legumes, chiefly red clover until 1918 and sweet clover since that time, have been seeded in the oats on the south half of Plot 4.

Summarizing the data from these Morrow plots into two periods, with the second period beginning in 1904, when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the untreated, continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oat production. The averages for the three-year system on the untreated land show a slight increase in corn yield, a small decrease in oats, and a considerable reduction in clover.

Crop rotation has noticeably improved the yields over continuous corn growing. The three-year rotation has been more effective than the two-year rotation in maintaining yields over the entire period. The two-year rotation, however, has

FIG. 8.—CORN ON THE MORROW PLOTS IN THE THREE-YEAR ROTATION

Both of these plots are under a good crop rotation of corn, oats, and clover. No soil treatment is applied to the plot at the left, while that at the right receives manure, limestone, and phosphate. The one is yielding at the rate of 50 bushels an acre, the other at 67 bushels.

been gaining on the three-year rotation in recent years probably because of the influence of sweet clover.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

Thruout the season the crops growing on the treated soil are usually at a more advanced stage of development than those growing on the untreated soil. In corn this shows up at husking time in drier, sounder ears than those found on the untreated land.

An important principle of soil management is demonstrated in these experiments; namely, that the best results are not obtained thru crop rotation alone nor thru soil fertilization alone, but it is the combination of these two practices that brings out the highest possibilities for production.

The practices in rotation and soil treatment which have been the most effective in increasing the crop-producing capacity of the soil have also been the most profitable financially. These better practices not only have increased the yields but they have made possible a greater economy in production, an important factor in increasing farm profits.

TABLE 11.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY

Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover[1]
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None	39.7	41.0	44.0	48.0	47.6	(2.03)
		25 crops	*12 crops*	*13 crops*	*9 crops*	*8 crops*	*8 crops*
1904 to 1928	None	25.0	35.1	34.0	49.3	45.1	(1.49)
	MLP	40.2	60.6	59.2	67.2	62.7	(2.83)

[1]Including all legume crops evaluated as clover hay.

For further information concerning these long-time soil experiments, the reader is referred to Bulletin 300, "Lessons from the Morrow Plots," where these investigations are described and discussed in detail.

THE KEWANEE FIELD

The Kewanee experiment field, representing the soil type Brown Silt Loam, is located in Henry county about midway between Kewanee and Galva. This field has been in operation since 1915. It includes 20 acres of the dark-colored loessial soil characteristic of the region. Altho the main soil type represented is Brown Silt Loam, a detailed examination reveals the presence of a second type occupying the basin of the draw which traverses the field in a winding direction. This minor type is classified as Black Clay Loam On Drab Clay. The topography of the land is rather rolling and it has a tendency to wash at certain spots. The field is laid out in two systems of plots designated as the major and the minor series.

The Major Series

A rotation system of wheat, corn, oats, and clover has been practiced on the major series, the crops being managed mainly as described on page 42. Since 1921 the clover on the residues plots has been harvested for hay instead of seed and the oat straw has not been returned to the land. Since 1922 the periodic application of limestone has been suspended after the different series had received an average total of 6¾ tons to the acre, and no more is to be applied until it shall be needed again. The practice of returning the wheat straw has been discontinued since 1922, and since 1925 only one crop of clover hay on the residues plots has been removed, the second crop being plowed down as green manure. The phosphate applications were suspended in 1927 after evening up all phosphate plots to a total of 4 tons per acre.

Table 12 gives a summary of the results showing the average annual yields for the different kinds of crops, including the years since the complete soil treatments have been in effect.

In looking over these results one may observe first the effect of animal manure, which has given profitable increases in all the crops. Residues alone show no significant effect.

Limestone in addition to manure has resulted in a small improvement, probably sufficient to cover the cost. It has been somewhat more effective in the grain system than in the livestock system.

Phosphorus, as usual, shows up in these averages to best advantage on the wheat crop in the residues system. Where used with manure and limestone, little effect was produced except on the wheat; but where used with residues and limestone, fair increases were produced in all crops, sufficient to return a financial profit under present market conditions. A study of the detailed data reveals a fact of interest in this connection which these averages do not bring out, and that is that the phosphate exerted very little influence during the earlier years of the experiments. Within the past seven or eight years, however, the

TABLE 12.—KEWANEE FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1917-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *10 crops*	Corn *12 crops*	Oats *12 crops*	Clover[1] *11 crops*
1	0	29.0	54.6	59.0	(1.64)
2	M	32.4	66.0	71.0	(2.23)
3	ML	35.2	70.6	73.2	(2.30)
4	MLP	40.0	72.1	72.4	(2.48)
5	0	30.3	56.1	60.6	(1.56)
6	R	31.6	58.2	59.6	(1.46)
7	RL	34.2	66.5	63.3	(1.71)
8	RLP	39.8	70.9	69.0	(1.89)
9	RLPK	40.6	74.4	70.6	(1.97)
10	0	28.1	50.3	56.4	(1.29)
	Crop Increases				
	M over 0	3.4	11.4	12.0	(.59)
	R over 0	1.3	2.1	− 1.0	−(.10)
	ML over M	2.8	4.6	2.2	(.07)
	RL over R	2.6	8.3	3.7	(.25)
	MLP over ML	4.8	1.5	− .8	(.18)
	RLP over RL	5.6	4.4	5.7	(.18)
	RLPK over RLP	.8	3.5	1.6	(.08)

[1]Including some seed evaluated as hay.

phosphorus treatment has come suddenly into evidence and the trend of its effectiveness seems at present to be on the upgrade.

No significant response appears as the result of potassium fertilization, thus indicating the futility of purchasing potassium fertilizer for use in this kind of a cropping system on this kind of soil.

Comparative Phosphate Experiments

Four short series having only 4 plots each constitute the so-called minor system on the Kewanee field. These plots are now given over to a comparison of the effectiveness of rock phosphate and superphosphate.

Alfalfa was grown on these plots until 1922. In the beginning, limestone was applied to Plots 3 and 4 at the rate of 4 tons an acre. This application was repeated in 1919. In 1922 the present experiments with phosphates were begun and the same rotation practiced on the larger series described above was established on these series. In this comparison rock phosphate is used on Plots 1 and 3 at the annual rate of 400 pounds an acre, applied once in the rotation ahead of the wheat, but beginning with 1927 rock phosphate will be applied at the same time as the superphosphate. Superphosphate is used on Plots 2 and 4 at the annual rate of 200 pounds an acre. It is applied twice in the rotation, one-half for wheat and one-half for oats. A summary of the annual crop yields and corresponding money values is given in Table 13.

In comparing these two forms of phosphate the following set of prices are assumed as representing the average market conditions for the past seven years

TABLE 13.—KEWANEE FIELD: PHOSPHATE EXPERIMENT

Average Annual Crop Yields and Corresponding Money Values 1922-1928
Bushels or (tons) per acre

Soil treatment applied	Wheat *7 crops*	Corn *7 crops*	Oats *7 crops*	Legume hay *7 crops*	Value per acre
Residues, rock phosphate	43.3	74.1	76.5	3.09	$43.89
Residues, superphosphate	45.1	73.0	78.2	3.02	44.17
Residues, limestone, rock phosphate	38.8	73.0	73.5	3.09	42.05
Residues, limestone, superphosphate	46.6	75.1	77.0	3.01	44.83

(December 1 quotations): wheat, $1.21 a bushel; corn, 68 cents; oats, 39 cents, and hay, $13.90 a ton. For the cost of the two phosphorus carriers, an estimate of $12 a ton for rock phosphate and $24 a ton for superphosphate may be taken, thus making the expense for the two kinds of phosphate equal.

With these prices applied to the yields given in Table 13, it is found that without limestone there is very little difference in value of crops produced under the two forms of phosphate. The 38 cents in favor of the superphosphate is scarcely significant in view of the experimental errors involved in this sort of test. In the presence of limestone the difference in crop values is $2.78 per acre per year in favor of superphosphate. Wheat has been the crop most affected by the form of phosphate applied.

It is to be borne in mind that the order of values can easily be shifted by a change in the relative yields of the respective crops or by a change in commodity prices. Furthermore no consideration has been given here to any possible difference in the residual effects of the two forms of phosphate which might appear upon discontinuing the treatments.

THE BLOOMINGTON FIELD

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat; and, since 1905, they have been grown in the sequence named.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. For 20 years all of the phosphorus on this field was applied in the form of steamed bone meal at the rate of 200 pounds an acre a year.

Table 14 presents a summary of the work to 1923 by average annual yields. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they were applied.

The value of limestone on this field is difficult to assess on account of the erratic results found upon comparing Plots 1 and 2. Here both corn and wheat appear to have suffered from the application of limestone, but the difficulty may well be attributable to soil variability. Comparing Plots 9 and 10, it would

TABLE 14.—BLOOMINGTON FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1902-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*	Clover[1] *3 crops*
1	0	44.6	40.6	26.5	(.74)
2	L	41.5	44.7	24.1	(.80)
3	LR	47.5	46.2	27.9	(.88)
4	LbP	55.8	54.3	45.7	(2.54)
5	LK	46.2	43.5	25.5	(.90)
6	LRbP	60.6	66.0	49.7	(1.19)
7	LRK	48.6	46.8	27.5	(.82)
8	LbPK	60.9	57.2	44.5	(2.44)
9	LRbPK	64.2	63.1	50.4	(.81)
10	RbPK	58.8	52.8	49.3	(.83)
	Crop Increases				
For limestone					
L over 0		− 3.5	4.1	− 2.4	(.06)
LRbPK over RbPK		5.4	10.3	1.1	−(.02)
For residues					
LR over L		6.0	1.5	3.8	(.08)
LRbP over LbP		4.8	11.7	4.0	−(1.35)
LRK over LK		2.4	3.3	2.0	−(.08)
LRbPK over LbPK		3.3	5.9	5.9	−(1.63)
For phosphorus					
LbP over L		14.3	9.6	21.6	(1.74)
LRbP over LR		13.1	19.8	21.8	(.31)
LbPK over LK		14.7	13.7	19.0	(1.54)
LRbPK over LRK		15.6	16.3	22.9	−(.01)
For potassium					
LK over L		4.7	− 1.2	1.4	(.10)
LRK over LR		1.1	.6	− .4	−(.06)
LbPK over LbP		5.1	2.9	− 1.2	−(.10)
LRbPK over LRbP		3.6	− 2.9	.7	−(.38)

[1]Two crops of seed on Plots 3, 6, 7, and 9 evaluated as hay.

appear that in combination with residues, phosphorus, and potassium, the limestone on the whole was beneficial.

The residues treatment, supplying organic matter and nitrogen, shows a beneficial effect on the grain crops, but not on the clover.

The prominent feature of the results on the Bloomington field is the effect of phosphorus. In all of the grain crops on every plot where bone meal was applied, there was a remarkable response to the treatment, as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues, with limestone, residues, and phosphorus) we find that the phosphorus treatment produced an average annual increase in the yield of corn of about 13 bushels an acre, while the yield of oats was increased by about 20 bushels, and that of wheat by about 22 bushels. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8, where potassium instead of residues was present.

Quite different are the results from the use of potassium on this field. The potassium was applied mainly in the form of potassium sulfate, but in 1917 when this material became unavailable thru war conditions, potassium carbonate was substituted. There was a moderate increase in the corn yield where potassium was used and particularly where residues were absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is the outstanding limiting factor in production and the application of this element in the form of steamed bone meal is attended by a high financial profit.

New Phosphate Experiments

In view of this remarkable response to bone meal on the Bloomington field, it was of interest to know how other carriers of phosphorus would behave, and accordingly some experiments were planned to investigate this question. For this purpose, the plots were divided in 1924 and certain new treatments were applied in order to compare the effects of rock phosphate and of superphosphate with bone meal, and at the same time to determine the residual effect of the accumulated phosphorus resulting from the continuous application of the bone meal in presumably somewhat excessive amounts.

The following modifications of the original plots were introduced:

An extra plot, No. 11, was added to the series and all plots were divided into north and south halves. Residues including cornstalks, the second crop of red clover, and other leguminous green manure crops are plowed down on all plots except Plot 1-S. Different phosphorus carriers are applied at the following acre rates per rotation: bone meal, 1000 pounds, to Plots 2-N, 4-N, 6-N, 8-N, 9-N, and 10-N; rock phosphate, 2500 pounds, to Plots 3-N, 5-N, 7-N, and 11-N; superphosphate, 1000 pounds, to Plots 3-S, 5-S, 7-S, and 11-S. Two-fifths of the rotation application of these phosphates are made preceding the oats crop, two-fifths ahead of the wheat crop, and one-fifth in preparation for the corn crop.

Table 15 indicates the arrangement of these modified plots and also gives the results of the five years in which these later experiments have been in progress.

In arriving at the financial results presented in the table, the values of the crops are based upon December 1 farm price quotations for the years in which the respective crops were produced. In deducting the annual cost for the different treatments, the total amounts of materials applied during the entire period of operation on the field were prorated. The expense for limestone is reckoned here at $3 a ton, rock phosphate at $14, superphosphate at $28, bone meal at $48, and residues at 75 cents an acre.

It should be mentioned in considering the results that the soil of these plots is rather variable, with little provision for duplication; and also that some of the treatments are not now strictly comparable with one another on account of the previous history of the plots. Nevertheless, making allowances for these facts, certain figures in the last column of the table showing the net average acre value per year indicate effects worthy of consideration.

TABLE 15.—BLOOMINGTON FIELD: NEW PHOSPHATE EXPERIMENTS
Crop Yields and Values 1924-1928—Bushels or (tons) and dollars per acre

Plot	Soil treatment applied		1924	1925	1926	1927	1928	Average annual acre values		
No.	Previous	Present	Oats	Clover	Wheat	Corn	Corn	Gross	Cost of treatment	Net
1-N	0	R	60.6	(.79)	29.3	49.8	49.0	$29.29	$ .75	$28.54
1-S	0	0	58.4	(2.54)	19.5	41.0	33.4	28.82	.....	28.82
2-N	L	RLP (bone)	72.6	(1.63)	35.0	58.6	52.2	36.18	6.55	29.63
2-S	L	RL	53.2	(.75)	18.7	46.0	35.2	23.41	1.75	21.66
3-N	RL	RLP (rock)	68.2	(2.18)	32.5	63.6	64.6	39.35	5.25	34.10
3-S	RL	RLP (super)	71.3	(1.74)	41.0	67.6	59.6	40.18	4.55	35.63
4-N	LP (bone)	RLP (bone)[1]	57.6	(1.81)	37.3	60.0	49.6	35.79	6.55	29.24
4-S	LP (bone)	RLP (bone)[2]	67.2	(1.89)	36.7	63.6	60.0	38.71	5.30	33.41
5-N	LK	RLKP (rock)	63.2	(1.66)	32.5	61.4	56.2	35.73	7.65	28.08
5-S	LK	RLKP (super)	78.4	(1.59)	40.7	69.4	55.6	39.99	6.95	33.04
6-N	RLP (bone)	RLP (bone)[1]	68.8	(2.18)	40.5	60.8	55.8	39.73	6.55	33.18
6-S	RLP (bone)	RLP (bone)[2]	71.6	(2.21)	40.0	64.2	60.4	41.09	5.30	35.79
7-N	RLK	RLKP (rock)	71.2	(2.11)	35.3	66.4	58.4	39.62	7.65	31.97
7-S	RLK	RLKP (super)	80.9	(1.66)	40.7	74.8	62.8	42.23	6.95	35.28
8-N	LKP (bone)	RLKP (bone)[1]	60.9	(1.69)	39.2	67.4	56.2	38.10	8.95	29.15
8-S	LKP (bone)	RLKP (bone)[2]	65.0	(1.59)	36.0	69.4	63.0	38.62	7.70	30.92
9-N	RLKP (bone)	RLKP (bone)[1]	60.9	(2.18)	43.8	75.8	60.4	42.56	8.95	33.61
9-S	RLKP (bone)	RLKP (bone)[2]	72.2	(1.65)	41.5	77.8	62.6	41.97	7.70	34.27
10-N	RKP (bone)	RKP (bone)[1]	48.2	(1.93)	45.7	56.6	51.2	37.02	7.95	29.07
10-S	RKP (bone)	RKP (bone)[2]	51.2	(1.53)	43.0	60.6	58.0	36.89	6.70	29.99
11-N	[3]	RP (rock)	70.4	(1.68)	45.3	61.8	47.4	38.43	4.25	34.18
11-S	[3]	RP (super)	60.0	(1.78)	44.5	63.0	57.2	39.11	3.55	35.56

[1]Bone meal applications omitted from 1917 to 1924. [2]No bone meal applied since 1917. [3]New plot added in 1924.

In answering the question as to whether other carriers of phosphorus would be as effective as the bone meal in building up this soil, attention is called to the results on Plots 2-N, 3-N, and 3-S where bone meal, rock phosphate, and superphosphate respectively have been employed in addition to limestone and residues. Unfortunately the comparison here is not altogether perfect in that the residues treatment on Plot 2-N was not introduced until 1924, whereas the other two plots had been under residues in the old system before the present experiments were begun and may, therefore, have an advantage in this respect over the bone meal plot. However this may be, the results as they stand at present place both rock phosphate and superphosphate ahead of bone meal.

Between rock phosphate and superphosphate four direct comparisons in different combinations with other materials are afforded (Plots 3, 5, 7, and 11.) In some years on some lots the results are in favor of superphosphate; in other years on the same plots the reverse is true. As the results stand at present, the majority are in favor of superphosphate but their inconsistency makes it difficult to come to any final conclusion. It may be noted that in these comparisons the two materials are not applied in amounts proportionate to equal cost as in other

cases reported. Here 200 pounds per acre per year of superphosphate figured at $2.80 are applied against 500 pounds of rock phosphate valued at $3.50 per acre per year.

For light on the question of residual effect of accumulated phosphorus in the soil, attention is called to the results on Plots 4, 6, 8, 9, and 10, where the north half-plots are now regularly receiving bone meal, while the south halves have received none since 1917. Invariably the net return is higher on the south half, thus indicating that the reserve phosphate accumulated in the soil from previous applications is still exerting a beneficial effect that is more than adequate to offset the expense involved in renewed applications.

By way of a summary of the main lessons brought out at this time by the Bloomington experiments, the following statements may be made.

The results indicate an outstanding phosphorus hunger.

This phosphorus need is satisfied by the application of either bone meal, rock phosphate, or superphosphate.

There is a pronounced residual effect from previous excessive applications of phosphorus carried in the form of bone meal.

THE MINONK FIELD

A University experiment field representing the soil type Black Clay Loam On Drab Clay is located in Woodford county near Minonk. This field was established in 1910. It comprizes 15 acres of dark-colored prairie soil of loessial and drift origin. The experiment plots lie mainly on Black Clay Loam On Drab Clay, altho a detailed examination reveals the presence of three other soil types distinguishable on account of certain profile characteristics. These are Brown Silt Loam, Brown Silt Loam On Calcareous Drift, and Brown Silt Loam On Calcareous Clay.

The field is laid out into four series of 10 plots each. The plots are one-fifth acre in size except in Series 100, where they are one-tenth acre. A crop rotation of corn, oats, clover, and wheat was practiced until 1923, when it was changed to corn, corn, oats, and wheat, with a seeding of hubam clover in the oats on all plots and biennial sweet clover in the wheat on the residues plots. In 1921 the practice of returning the oat straw on the residues plots was discontinued, and in 1922 the return of the wheat straw was likewise discontinued. Up to that time limestone, varying in total quantity from 7½ to 9 tons an acre on the different series, had been applied. These applications were then suspended until such time as the need for more lime becomes apparent. The applications of rock phosphate were likewise indefinitely suspended in 1923 after evening up the total applications to 4 tons an acre on all the phosphate plots.

The average annual yields of all crops produced since the complete soil treatments have been in effect are given in Table 16.

In looking over these results, one observes from the good yields on the untreated plots the naturally high productiveness of this land. There is more or less response to farm manure; in the corn the yield is markedly increased by its use. Residues alone have likewise increased the yields of the grain crops. Limestone seems to have had no material effect on crop yields. Evidently this

TABLE 16.—MINONK FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1912-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Corn	Oats	Clover[1]	Soybeans	Stubble clover	
							Hubam	Sweet clover
		14 crops	*23 crops*	*16 crops*	*5 crops*	*4 crops*	*2 crops*	*2 crops*
1	0	30.1	50.2	58.8	(2.58)	19.3	(.72)	.....
2	M	33.8	60.6	61.3	(2.81)	20.5	(.94)	.....
3	ML	32.4	61.0	60.3	(2.74)	21.7	(.83)	.....
4	MLP	34.4	61.0	59.2	(2.93)	21.0	(.97)	.....
5	0	31.4	48.6	55.5	(1.36)	20.7	(.86)	.....
6	R	33.8	59.3	61.7	(1.50)	20.6	(.91)	(1.19)
7	RL	30.8	61.1	61.6	(1.51)	19.3	(.90)	(1.16)
8	RLP	32.7	62.3	63.0	(1.47)	19.7	(1.06)	(1.33)
9	RLPK	32.0	59.9	63.2	(1.49)	17.2	(1.20)	(1.50)
10	0	26.1	44.0	55.2	(2.30)	15.3	(.58)	.....
	Crop Increases							
	M over 0	3.7	10.4	2.5	(.23)	1.2	(.22)	.....
	R over 0	2.4	10.7	6.2	(.14)	− .1	(.05)	(1.19)
	ML over M	− 1.2	.4	− 1.0	−(.07)	1.2	−(.11)	.....
	RL over R	− 3.0	1.8	− .1	(.01)	− 1.3	−(.01)	−(.03)
	MLP over ML	2.0	0.0	− 1.1	(.19)	− .7	(.14)	.....
	RLP over RL	1.9	1.2	1.4	−(.04)	.4	(.16)	(.17)
	RLPK over RLP	− .7	− 2.4	.2	(.02)	− 2.5	(.14)	(.17)

[1]Including some seed evaluated as hay.

soil does not need lime. The use of rock phosphate has not been profitable either in the manure or the residues system. Potassium, as used in these experiments, has likewise been ineffective.

These results therefore indicate the advisability of furnishing plenty of organic matter, either thru stable manure or thru crop residues, including leguminous green manure, as the best practical means, for the present, of improving the productiveness of this naturally fertile soil. As time goes on, with changing soil conditions and shifting market values, the situation may develop under which a different recommendation will be warranted.

THE HARTSBURG FIELD

Black Clay Loam as noted on page 17, occupies about 87 square miles in Coles county. The results of the Hartsburg field, situated in Logan county just east of the town of Hartsburg, are suggestive of the treatments that are effective on this type of soil.

The Hartsburg field was started in 1911. It is laid off in five series of 10 plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series.

The crops were handled mainly as described on page 42 until 1918 when it was planned to remove one hay crop and one seed crop of clover from the residues

TABLE 17.—HARTSBURG FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1913-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Barley	Corn	Oats	Clover	Soybeans	Alfalfa	Stubble clover	
									Hubam	Sweet-clover
		13 crops	*1 crop*	*24 crops*	*17 crops*	*7 crops*	*2 crops*	*8 crops*	*1 crop*	*1 crop*
1	0	24.9	35.4	48.1	48.1	(1.84)	(1.29)	(3.47)	(.83)	.....
2	M	29.2	44.2	58.8	52.9	(2.16)	(1.64)	(3.67)	(1.15)	.....
3	ML	34.0	50.0	64.5	58.3	(2.32)	(1.82)	(3.91)	(.91)	.....
4	MLP	36.2	50.0	63.8	57.8	(2.39)	(1.92)	(4.19)	(1.17)	.....
5	0	29.7	42.7	53.3	47.0	(1.28)	25.8	(3.33)	(.71)	.....
6	R	32.7	47.5	63.7	53.3	(1.67)	26.8	(3.78)	(.75)	(.85)
7	RL	30.1	53.3	66.9	51.3	(1.64)	28.4	(3.45)	(.68)	(.75)
8	RLP	34.3	46.9	67.3	55.4	(1.79)	26.1	(4.04)	(.72)	(.90)
9	RLPK	33.4	55.6	65.4	54.5	(1.70)	26.4	(4.16)	(.80)	(1.00)
10	0	30.5	45.8	52.8	48.0	(2.02)	(1.69)	(3.20)	(.75)	.....
	Crop Increases									
	M over 0	4.3	8.8	10.7	4.8	(.32)	(.35)	(.20)	(.32)	.....
	R over 0	3.0	4.8	10.4	6.3	(.39)	1.0	(.45)	(.04)	(.85)
	ML over M	4.8	5.8	5.7	5.4	(.16)	(.18)	(.24)	−(.24)	.....
	RL over R	− 2.6	5.8	3.2	− 2.0	−(.03)	1.6	−(.33)	−(.07)	−(.10)
	MLP over ML	2.2	0.0	− .7	− .5	(.07)	(.10)	(.28)	(.26)	.....
	RLP over RL	4.2	− 6.4	.4	4.1	(.15)	− 2.3	(.59)	(.04)	(.15)
	RLPK over RLP	− .9	8.7	− 1.9	− .9	−(.09)	.3	(.12)	(.08)	(.10)

plots. In 1921 it was decided to harvest all the clover as hay. At that time the return of the oat straw to the land was discontinued. In 1922 the return of the wheat straw was likewise discontinued. The application of limestone was discontinued in 1922 after amounts ranging from 7½ to 10 tons an acre on the different series had been applied, and no more will be added until further need for it becomes apparent. In 1923 the phosphate applications were evened up to a total of 4 tons an acre on all phosphate plots, and no more will be applied for an indefinite period. At that time the rotation on the first four series was changed to corn, corn, oats, and wheat with a seeding of hubam clover in the oats on all plots, and a seeding of biennial sweet clover in the wheat on the residues plots. The rotation was changed also on the fifth series to corn, oats, wheat, and a mixture of alfalfa with red clover. The soil treatments are as indicated in Table 17, which summarizes by crops the yields for the period during which the plots have been under full treatment.

The outstanding feature of the results on the Hartsburg field is the large increases produced by organic manure whether in the form of crop residues or stable manure. The behavior of limestone is rather peculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure it shows some increase in practically all crops, while with residues its effect on several of the crops appears negative.

Altho rock phosphate has given some increases in wheat yield in both the manure and the residues systems, the results with other crops have been such

as to render the use of this material unprofitable on this field. The addition of potassium appears to have produced no significant effect excepting on the one barley crop.

THE TOLEDO FIELD

As representative of Gray Silt Loam On Tight Clay, the Toledo experiment field, which lies only about eight miles south of Coles county, may be taken. This field of 17 acres was established in 1913. It was laid out into two separate systems of plots, one including four series of ten plots each and the other containing four series of four plots each.

On the larger series the plots have been maintained, for the most part, under the systems of cropping and treatment described on page 42. In 1922 the application of limestone was discontinued. The plots had received a total of 6½ to 8 tons an acre on the different series, and no more will be applied until the need for lime becomes apparent. Two years later the application of rock phosphate was likewise discontinued after a total of 4 tons to the acre had been applied.

Table 18 presents a summary of the crop yields including the years in which the complete plot treatments have been in effect. The results are characteristic of those generally obtained on this gray prairie soil, namely: very poor yields on the untreated land and a very high response to limestone and organic matter.

Manure alone has had relatively little effect and residues alone has had even less.

Limestone has had a very pronounced effect in increasing the yields of all crops.

TABLE 18.—TOLEDO FIELD: SUMMARY OF CROP YIELDS

Average Annual Yields 1914-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *11 crops*	Corn *15 crops*	Oats *14 crops*	Clover or mixed hay *7 crops*	Soybeans *3 crops*	Sweet clover *3 crops*
1	0	8.8	21.9	15.1	(.10)	(.70)	.11
2	M	10.7	28.6	18.5	(.22)	(.72)	.24
3	ML	22.0	40.7	29.7	(1.18)	(1.27)	2.45
4	MLP	23.4	40.3	30.4	(1.25)	(1.21)	2.42
5	0	7.8	17.6	14.4	(.10)	(.38)	.26
6	R	9.0	19.3	16.2	(.23)	(.47)	.53
7	RL	20.6	28.6	31.1	(1.35)	(.94)	1.84
8	RLP	23.5	29.5	32.3	(1.54)	(1.05)	1.77
9	RLPK	28.1	41.0	35.7	(1.82)	(1.18)	2.48
10	0	6.8	15.4	15.4	(.17)	(.53)	.19
		Crop Increases					
M	over 0	1.9	6.7	3.4	(.12)	(.02)	.13
R	over 0	1.2	1.7	1.8	(.13)	(.09)	.27
ML	over M	11.3	12.1	11.2	(.96)	(.55)	2.21
RL	over R	11.6	9.3	14.9	(1.12)	(.47)	1.31
MLP	over ML	1.4	— .4	.7	(.07)	—(.06)	— .03
RLP	over RL	2.9	.9	1.2	(.19)	(.11)	— .07
RLPK	over RLP	4.6	11.5	3.4	(.28)	(.13)	.71

There has been only a very limited response to rock phosphate—not enough in either the manure or the residues system to pay for the cost of the material.

Potassium has produced a beneficial effect on all crops, becoming very pronounced on the corn. The experiments show only the effect of potassium as used in the combination with residues, limestone, and rock phosphate.

Tillage Experiments

The second set of plots on the Toledo field has been devoted mainly to an investigation in soil tillage, the purpose being to compare the effects of subsoiling, deep tilling, and dynamiting with that of ordinary plowing. A crop rotation of corn, soybeans, wheat, and sweet clover was adopted, second-year sweet-clover stubble being plowed late in the fall for corn. An application of 4 tons of limestone an acre was made on all plots in 1913; 3 tons were applied for the 1917 crop, and 2 tons for the 1921 crop. One ton of rock phosphate was applied in the fall of 1914, and again in the fall of 1918.

A summary of the crop yields is given in Table 19. For a detailed account of these experiments the reader is referred to Bulletin 258 of this Station, "Experiments with Subsoiling, Deep Tilling, and Dynamiting."

TABLE 19.—TOLEDO FIELD: TILLAGE EXPERIMENTS

Average Annual Yields 1913-1922—Bushels per acre

Tillage treatment	Corn *9 crops*	Soybeans *7 crops*	Wheat *6 crops*	Sweet-clover seed *6 crops*
Plowed 7 inches deep	40.2	16.3	13.5	3.68
Subsoil 14 inches deep	41.9	16.2	12.9	3.65
Deep-tilled 14 inches	37.4	15.2	10.8	3.18
Dynamited	40.3	16.4	11.7	4.25

The conclusions reached from the results of these experiments is that none of the special tillage treatments had any beneficial effect on crop yields. Deep tilling apparently decreased yields, probably because of the mixing of subsurface and subsoil with the surface soil.

THE VIENNA FIELD

Coles county, as indicated in the descriptions of certain of its soil types, includes considerable land that is subject to destruction thru erosion or washing. Yellow Silt Loam, which occupies about 29 square miles in the county, is particularly susceptible to this kind of damage. Operators of land in Coles county will therefore be interested in experiments conducted on the Vienna field, in Johnson county, to test out different methods of reclaiming badly gullied land and preventing further erosion.

The Vienna field is representative of the sloping, erodible land so common in the extreme southern part of the state. When the experiments were started the whole field, with the exception of about three acres, had been abandoned because so much of the surface soil had washed away, and there were so many gullies that further cultivation was unprofitable. For the purpose of the experi-

FIG. 9.—PROPER SOIL AND CROPPING METHODS WOULD HAVE PREVENTED THIS CONDITION
This abandoned hillside is just over the fence from the field shown in Fig. 10. Yellow Silt Loam is particularly susceptible to this kind of damage.

ments the field was divided into different sections (see Table 20). These were not entirely uniform; some parts were much more washed than others, and portions of the lower-lying land had been affected by soil material washed down from above. The higher land had a very low producing capacity; on many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except the one designated as D, which included but three plots.

TABLE 20.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields, 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

Section A included the steepest part of the field and contained many gullies. The land was built up into terraces at vertical intervals of 5 feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

Section B was used to test the so-called embankment method. Ridges were plowed up which were sufficiently high so that when there were heavy falls of rain the water would break over and run in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about 8 loads of manure an acre were turned under each year for the corn crop.

Section D was washed to about the same extent as Section C. It was farmed in the most convenient way, without any special effort to prevent washing.

Fig. 10.—Corn Growing on an Improved Hillside of the Vienna Experiment Field
This land had formerly been badly eroded. It was reclaimed by proper soil treatment and cropping. Compare with Fig. 9.

Careful records were kept for nine years. The results, summarized in Table 20 indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels on the check series (D). Wheat yielded 11.1 bushels on the protected series, in comparison with 4.6 bushels on the check, and clover yielded ⅘ of a ton on the protected series and but ⅕ of a ton on the check.

Figs. 9 and 10 serve further to indicate what may be done with this type of soil even after it has become badly washed and gullied.

Altho these results show in principle the possibility of improving this land, it cannot be said that the experiments as conducted represent directly the most economical system of farming. However, it appears possible that by modifying the cropping plan in some manner, as for example, substituting sweet clover for cowpeas and giving large place in the farming system to hay and pasture crops, production might be substantially increased and thus a system of farming instituted that would represent a profitable enterprise.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1925
33 Saline, 1926
34 Marion, 1926
35 Will, 1926
36 Woodford, 1927
37 Lee, 1927
38 Ogle, 1927
39 Logan, 1927
40 Whiteside, 1928
41 Henry, 1928
42 Morgan, 1928
43 Douglas, 1929
44 Coles, 1929

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 45

MACON COUNTY SOILS

By R. S. SMITH, E. A. NORTON, E. E. DeTURK, F. C. BAUER, and L. H. SMITH

URBANA, ILLINOIS, DECEMBER, 1929

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Macon county was conducted, and Mr. F. W. Wascher, who, as leader of the field party, was in direct charge of the mapping.

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MACON COUNTY SOILS

By R. S. SMITH, E. A. NORTON, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

HISTORICAL REVIEW

Macon county is located near the center of Illinois. It is rectangular in shape, 27 miles north and south by about 21 miles east and west, and comprizes 581 square miles. The population in 1920 was 65,175, about one-third of which was rural. Decatur is the principal town and the county seat.

Much of the prairie was originally swampy and poorly drained, but since the establishment of artificial drainage, the excess surface water is quickly removed and the land is generally well drained. The surface of the county is a gently rolling plain broken by narrow belts of more rolling to slightly hilly country bordering the major stream valleys. Decatur lake, some 13 miles long and covering 5½ square miles, which was formed by confining water in the Sangamon river bottom land, is a recreational center for the community and furnishes the city of Decatur with an adequate water supply.

Macon county lies near the southern border of the fertile corn-belt section of the United States. Its soils are generally dark-colored, rich, and highly productive. The rainfall, temperature, and growing season are favorable for the growth of a wide variety of crops. Markets are close at hand and railroad transportation, both steam and electric, is so well developed that no farm in the county is more than seven miles from a shipping center. Recently built concrete roads, more than sixty miles of which radiate in all directions from the county seat, are playing an important role in further development. The dirt roads are well kept and are good except during the rainy seasons. Many of them are coated with oil annually and these seldom break up. The combination of all of these favorable factors has produced a highly developed agriculture thruout the county. Farm buildings and equipment indicate general prosperity. Educational facilities and social life are of the highest type of rural development.

The first white man to come into the area now included in Macon county was Joseph Stevens. He established the first community on the north bank of Sangamon river near the present site of the city of Decatur early in the nineteenth century. Most of the early settlers were natives of Kentucky, Tennessee, and North Carolina. Following 1820 the population grew rapidly as people came in from Ohio, Pennsylvania, and other eastern states. The more rolling parts of the county were settled first, and as fast as the land was drained, the entire area became populated. The region was originally part of Shelby county, but the present definite boundaries were made in 1829, when Macon county was created by an act of the Legislature. The first railroad to be constructed in the county was completed in 1852. A rapid expansion in both industry and agriculture followed.

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[1]R. S. Smith, in charge of soil survey mapping; E. A. Norton, assistant chief in soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

AGRICULTURAL PRODUCTION

Early agriculture in Macon county was confined to raising enough food to meet the needs of home consumption. Vegetables, fruits, hay, and cereals were the chief crops. Livestock was raised, fattened, and driven overland to St. Louis to market. Much of the land remained in grass which served as pasture or was cut for hay. Surplus grain crops were not grown in the early days because of the lack of a market. Following the completion of railroad connections out of Springfield in 1842, some grain was hauled from Macon county and marketed there. According to early reports, wheat sold for 28 to 35 cents a bushel, but corn did not usually bring enough to pay for hauling it any distance. For the same reason very little oats, rye, or barley was grown. Expansion in agriculture was limited by the lack of transportation in this early period. It was natural, then, that following the completion of the first railroad in 1852, agriculture progressed rapidly. Attention was first given to draining the flat prairie land and increasing crop acreage. The area in farms increased from 30,000 acres in 1850 to more than 200,000 acres in 1870, and by 1880 there were nearly 340,000 acres in farms. Shortly after this, all the available farming area in the county was being utilized. The number of farms increased from 360 in 1850 to 2,872 in 1880, but thereafter there was a gradual decline to 2,441 in 1925. This decline in the number of farms has been attended by an increase in the acreage per farm. In 1880 the average size of farms was 127 acres, while in 1925 it was 142 acres.

The increase in the value of farms during the period from 1850 to the present gives an indication of the rapid development that has taken place in the agriculture of the county. In 1850 the value of farms, including buildings and equipment, was slightly less than one million dollars. Values increased 4 to 6 million dollars every decade from 1850 to 1900, when they jumped from 27½ to 67½ million dollars. During the World War period, when the average selling price of land was more than $300 an acre and some farms sold for more than $400 an acre, the value of farm property increased to more than 120 million dollars but has since declined to about 75 million.

The rapid increase in the area under cultivation is indicated by Fig. 1, which shows the acreage in corn, oats, and wheat in certain years during the period from 1850 to the present. The corn acreage expanded very rapidly for the first thirty years and reached a peak about 1900, when nearly one-half of the farm acreage in the county was in corn. Fig. 1 shows the acreage of wheat surpassing that of oats in the early period but declining after 1880. The increase in wheat acreage in 1920 was the result of war stimulation. The acreage seemed to regain normalcy by 1922. The total acreage in corn, oats, and wheat in 1928 was about 8 percent less than the average from 1900 to 1920. This does not mean a falling off in total crop production but rather that more of the acreage is being utilized for legumes and other crops.

The principal crops grown in Macon county are those common to the corn belt. The following data, taken from the United States Census of Agriculture made in 1925, gives the acreage, production, and yield per acre of the common crops for 1924.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn, total acreage	143,139	.....	.....
Harvested for grain	139,219	5,593,349 bu.	40.2 bu.
Cut for silage	636	5,414 tons	8.5 tons
Cut for fodder	1,917	.....	.....
Hogged off	1,367	.....	.....
Wheat	35,250	571,954 bu.	16.2 bu.
Oats, threshed for grain	48,361	2,041,972 bu.	42.2 bu.
Oats, cut and fed unthreshed	634	.....	.....
Hay of all kinds	30,343	36,091 tons	1.19 tons
Timothy	5,215	.....	.....
Timothy and clover mixed	4,442	.....	.....
Clover	13,564	.....	.....
Alfalfa	1,664	.....	.....
Sweet clover	1,243	.....	.....

These census figures are for but a single year, and they will fluctuate from season to season, depending largely on climatic conditions. For that reason, the average yield over a period of years more nearly represents the conditions. For the past ten-year period, the U. S. Department of Agriculture gives the average yield of corn as 37.6 bushels; oats, 31.6 bushels; wheat, 18.8 bushels; hay, 1.4 tons.

The trend of yields per acre of the common crops in Macon county has been slightly upward since 1900. The average yield of corn for the ten-year period ending in 1899 was about 30 bushels per acre. The past ten-year period shows a 25 percent increase over this figure. The increase for wheat during the same

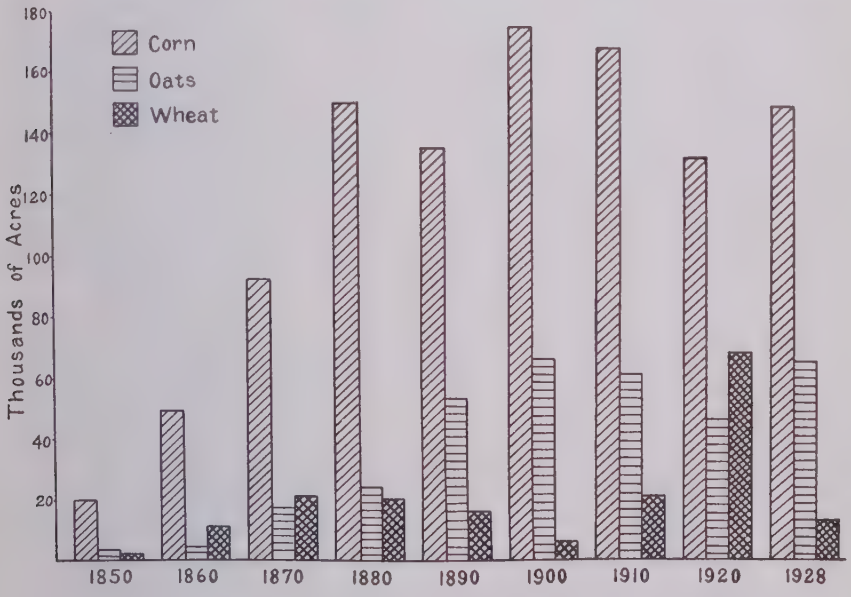


FIG. 1.—ACREAGE OF CORN, OATS, AND WHEAT IN MACON COUNTY

The diagram shows the relative acreage devoted to the three principal grain crops at periodic intervals since 1850. (Figures from U. S. Census, except for 1928, for which estimates of the U. S. Bureau of Agricultural Economics and the Illinois State Department of Agriculture are used.)

period has been more than 30 percent and for tame hay about 20 percent, while that for oats has been less than 2 percent. The problem connected with variation in yields per acre is complex but the above figures indicate that the decrease in soil fertility is more than balanced by better farming methods.

The predominance of acreage given over to the growing of corn and oats, as shown in Fig. 2, suggests that more diversification of crops might well be practiced if production is to keep pace with waning fertility. In 1928 the area devoted to alfalfa increased to nearly 2,000 acres, and that of sweet clover to

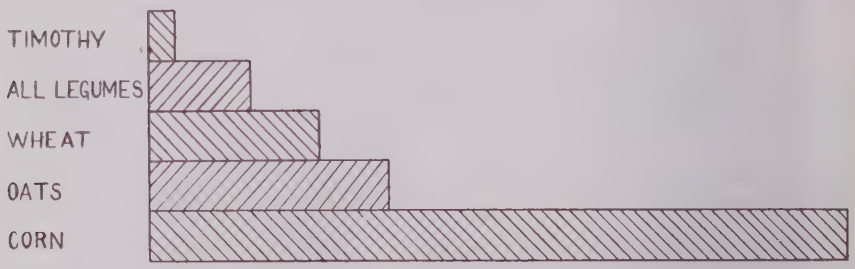


FIG. 2.—RELATIVE ACREAGE OF FIELD CROPS IN MACON COUNTY, 1924

The diagram brings out the preponderance of land devoted to the three grain crops, corn, oats, and wheat. Legume crops might well occupy a larger proportion of the cultivated acreage (data from the 1925 Census).

nearly 4,000. Soybeans have recently become an important crop, replacing some of the oat acreage. In 1928 there were 15,500 acres of soybeans grown in the county, 1,500 acres of which were sown with corn.

Fruit and vegetable crops are not commercially important in Macon county. Some trucking is practiced near Decatur. Practically all such products raised are consumed on the farm or disposed of locally. In 1925 there were 445 acres devoted to vegetables; 185 acres of white potatoes yielded 17,360 bushels; and most of the remaining acreage was in sweet corn. Apples and peaches are the most important fruits. Some grapes are grown.

The number of livestock in the county increased rapidly following 1850, but this increase did not keep pace with the increase in grain production so that Macon soon became a grain-exporting county. Fig. 3 shows the number of horses, mules, cattle, and hogs in the county in certain years during the period from 1850 to the present. The increase from 1870 to 1890 was very marked, especially in the number of hogs. Between 1890 and 1910 there was a sharp decline in total livestock. Since 1910 the number has remained about stationary. A notable decrease in the number of horses and mules occurred between 1920 and 1928. Sheep have never been very numerous in Macon county. There were nearly 10,000 head in 1870, but since then the number has decreased considerably. There have been fewer than 5,000 in the county since 1920.

The character of the livestock interests in the county in 1924 is shown by the following figures taken from the Census:

Animals and Animal Products	*Number*	*Value*
Horses	12,710	$1,028,734
Mules	2,162	188,664
Cattle (total)	21,479	1,011,525
Dairy cows	8,301	.....
Dairy products	.....	529,026
Sheep	4,211	49,246
Hogs	35,335	477,676
Chickens and eggs sold	.....	583,432
Wool	.....	6,213

Estimates made by the U. S. Department of Agriculture and the Illinois State Department of Agriculture, as of January 1, 1929, indicate that the number

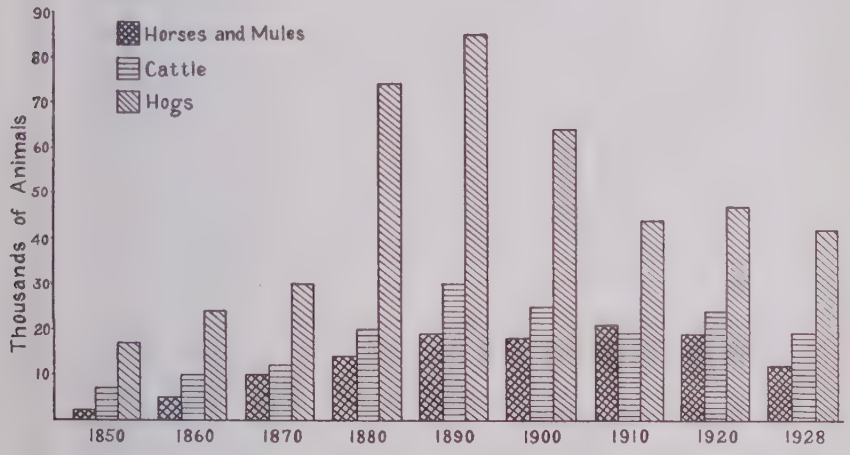


FIG. 3.—NUMBER OF HORSES AND MULES, CATTLE, AND HOGS IN MACON COUNTY

The diagram shows the relative numbers of the principal classes of livestock at periodic intervals since 1850. (Figures from U. S. Census, except for 1928, for which estimates of the U. S. Bureau of Agricultural Economics and the Illinois State Department of Agriculture are used.)

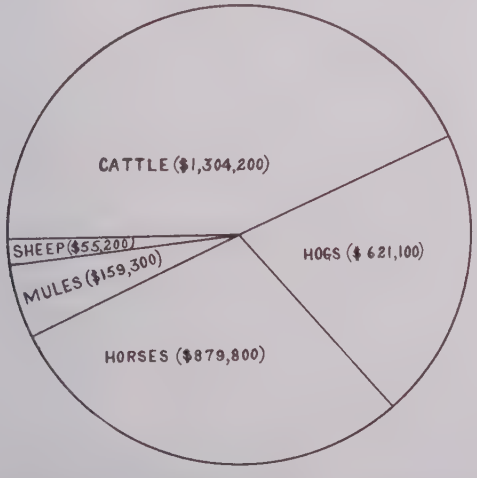


FIG. 4.—RELATIVE VALUE OF THE MORE IMPORTANT CLASSES OF FARM ANIMALS IN MACON COUNTY IN 1929

of horses and mules in Macon county has decreased nearly 3,000 and that of cattle nearly 2,600 since 1925. The number of hogs shows an increase. Fig. 4 shows the relative value of the more important classes of farm animals in 1929. The value of all cattle, as shown in Fig. 4, is nearly as much as that of horses and hogs combined. Mules and sheep are of least importance.

CLIMATE AND PHYSIOGRAPHY

The climate of Macon county, which is typical of the central part of Illinois, is characterized by a wide range between the extremes of winter and summer and by an abundant, usually well-distributed rainfall. The greatest range in temperature for any one year of the thirty-four year period, 1895 to 1929, as recorded at the Weather Bureau Station located in Decatur, was 126 degrees in 1918. The highest temperature recorded was 109° in 1901, the lowest 25° below zero in 1905. The mean summer temperature is about 74°; the mean winter, 29°; and the mean annual, about 52°. The average date of the last killing frost in the spring is April 23; the earliest in fall is October 13. The average length of growing season is 173 days, which is ample for the maturing of the common crops grown in the region. Early frost following a backward season has produced soft corn several times during the last decade, but usually the corn ripens before killing frost comes. Winter wheat is often injured, particularly on flat land, owing to a sudden drop in temperature and consequent freezing following a rainy period in winter or early spring. A short period of extreme hot weather occasionally cuts the yield of small grains in early summer. The temperature in general is, however, favorable for crop growth and maturity.

The prevailing wind direction in spring and summer is southwest; in winter, northwest. Spring winds are usually brisk and those of summer more gentle except before thunder storms. Macon county lies within the region subject to tornadoes but none resulting in serious destruction are known to have visited the county. A series of strong northwesterly gales which bring cold waves, followed by periods of relative calm, characterize the winds of winter.

The average annual rainfall, as recorded at Decatur for the last 34-year period, is 38.07 inches. About half of this amount falls during the growing season. The wettest year on record, 1927, had a total rainfall of 60.58 inches, while 1926 had a total of 58.68 inches. The driest year on record, 1914, had a total rainfall of 25.10 inches. As an illustration of extremes, it is noted that 16.56 inches of rain fell in September, 1926, and only .07 inch in November, 1904. Rainfall in Macon county is so well distributed that there has never been a severe drouth. Occasionally twenty to thirty days pass without much rain so that crop yields are reduced and meadows and pastures are short, but the subsoil has never been thoroly dried out so that plant roots could not obtain moisture. Fig. 5 shows the average monthly distribution of rainfall in the county. Much of the precipitation of the winter months is snow. The average annual snowfall in the county is about 23 inches. Sleet storms are not uncommon. Occasional hailstorms occur in early summer but damage as a result of them is usually local.

The rate at which the rain falls has an important bearing both on moisture available to plants and on soil erosion. No records on the rate of rainfall are

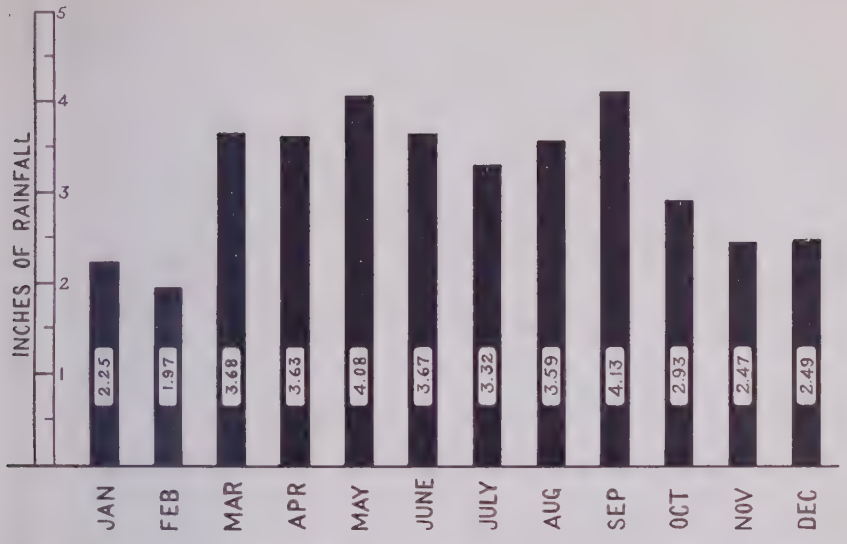


FIG. 5.—THE AVERAGE MONTHLY DISTRIBUTION OF RAINFALL IN MACON COUNTY
It will be noted that the more abundant rainfall occurs mainly during the growing season. This, of course, is favorable to crop production.

available but much of the water which falls, from both prolonged spring rains and hard dashing thunder showers in summer, is perhaps more destructive than beneficial. Several rains of that kind occur in this section almost every year. The control of erosion on cultivated areas, particularly on rolling land, is a serious problem. The accumulation of temporary ponds on flat land following hard rains damages crops by drowning. Losses from erosion and drowning were particularly noticeable during the wet years of 1926 and 1927.

The general elevation of Macon county is between 600 and 700 feet above sea level. The advance and deposit of the last ice sheet to cover central Illinois built up a ridge, the Shelbyville moraine, back of which the land level is some 70 feet higher than below the moraine. This ridge is about three miles wide, extending in a north-south direction just west of the center of the county. The ridge has rolling topography, but otherwise the county is flat to gently rolling except for the narrow rolling strips adjacent to the principal drainage courses. Here the present topography is the effect of erosion. There are two particularly flat-lying regions in the county located in the northwestern and southeastern parts. All the land except a very narrow belt adjoining the Sangamon river bottom land northeast of Decatur can be cultivated. The altitudes of a few towns in Macon county are as follows: Argenta, 692 feet above sea level; Blue Mound, 620; Decatur, 678; Hervey City, 699; Macon, 727; Maroa, 720; Niantic, 606; Oakley, 692; Warrensburg, 709.

Natural drainage in Macon county is fairly well established. Sangamon river and its tributaries drain all but a few sections in the southeast part of the county. Drainage in this area is southeast into Kaskaskia river. The southwestern part of the county drains into South Fork which empties into Sangamon river in Sangamon county. The northwestern part of the county drains into

Lake Fork, a tributary of Salt creek, which flows west emptying into Sangamon river about 30 miles west of the county line. Fig. 6 shows the stream courses, main dredges, and other physiographic features of Macon county.

Much of the original prairie surface in the county was wet and numerous shallow ponds existed because of the lack of an outlet for the water. The extension of natural drainage lines by dredges and ditches has provided proper outlets and this, in addition to tile, has made the land generally well drained. There

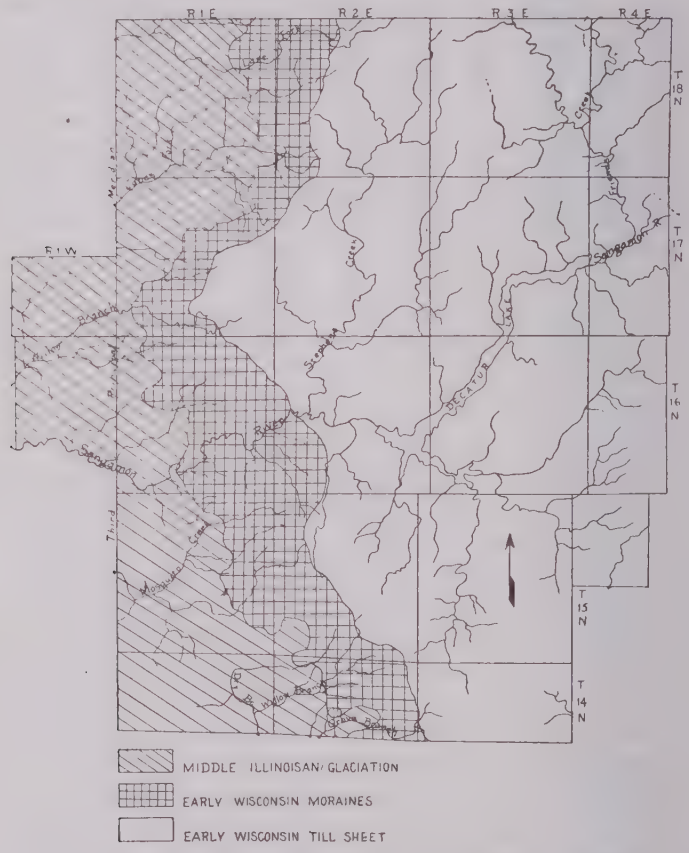


FIG. 6.—DRAINAGE MAP OF MACON COUNTY SHOWING STREAM COURSES AND OTHER PHYSIOGRAPHIC FEATURES

are a few areas, particularly in the northwestern part of the county, which are not yet perfectly drained. Excessive rainfall still causes some damage in the flatter parts of the county because artificial drainage was provided to care for only a moderate amount of run-off.

The soils in the county as a whole are of such nature as to allow freedom of water movement, provided a drainage outlet is established. There are a few areas in the northwestern part of the county and south of the town of Macon with sticky, plastic, and tight subsoil. Special attention must be given to surface ditching to remove excess surface water on these areas, as the subsoil is but

slowly pervious to water and tiling alone is not adequate. Except for these few areas, all soils in the county can be properly drained by tiling and good soil moisture conditions maintained.

SOIL FORMATION

ORIGIN OF SOIL MATERIAL

The most important period in the geological history of the county, from the standpoint of soil formation, was the Glacial epoch. The sequence of events of earlier earth history which led to the formation of the bed rock foundation underlying this area is of minor importance because the source of mineral material for the soils as well as the present topography is largely the result of glacial action. It is sufficient to know that the bed rock was formed and elevated to its present position during some remote geological era. The bed rock surface was subject to the forces of rock destruction and removal for an extended period during which the country became rough and broken in character. The hills and valleys produced as a result of erosion were not well suited to agriculture and were in great contrast to the present lay of the land. During the Glacial epoch the material that later constituted the mineral portion of the soils was deposited and the present topography formed.

At the time of the Glacial epoch the climate was colder than at present and snow and ice accumulated in regions to the north in such an amount that the mass pushed outward from these centers. The movement advanced, chiefly southward, aided by further accumulations of snow at its margin, until a place was reached where the climate was warm enough to melt the ice as rapidly as it advanced. In moving across the country from the far north, the ice gathered up all sorts and sizes of materials, including clay, sand, gravel, boulders, and even immense masses of rock. Some of these materials were carried hundreds of miles and rubbed against surface rocks and each other until largely ground into powder. The greater part of material carried was derived from the old eroded bed rock surface and usually deposited less than fifty miles from its origin. When the ice sheet, or glacier, reached the limit of its advance, the rock material carried by it accumulated along the front edge in a broad undulating ridge or moraine. With rapid melting, the glacier receded and the material was deposited somewhat irregularly over the surface of the area previously covered. The advance and recession of the glacier were not uninterrupted movements but were complex in character. Local oscillations of the ice were frequent. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift. The average depth of this deposit over the state of Illinois is estimated at 115 feet.

At least six great ice sheets moved southward, each of which covered a part of North America, altho the same parts were not covered during each advance. The advance and retreat of these individual ice sheets were separated by long periods of time during which the climate was normal and the country clothed with vegetation. At least two and perhaps more of the glaciers reached Macon county. The Illinoian glaciation completely covered the county and buried or

destroyed the deposits which might have been left by an earlier ice sheet. The last glaciation, known as the Wisconsin, advanced from the northeast across the eastern two-thirds of the county. Its terminus is marked by the broad undulating ridge, known as the Shelbyville moraine, which crosses the county in a north-south direction west of its center (see Fig. 6). This ice sheet deposited from 50 to 120 feet of material over that part of the county which it crossed and on top of the deposit left by the Illinoian. This explains the general higher elevation of the eastern part of the county. Another ridge, known as the Cerro Gordo moraine, was built up during the recession of the Wisconsin glaciation. This moraine enters the county northeast of Oakley and extends in a southwesterly direction, disappearing a few miles north of Casner (see Fig. 6). The topography of that part of the county not covered by the Wisconsin ice sheet is more level and except for a few isolated mounds, such as those one mile west of Blue Mound, the surface is generally flat. The general effect of these glaciers was to change the surface from hilly to gently undulating by filling in the valleys and rubbing down the hills.

Associated with the withdrawal of an ice sheet and exposure of the deposited material to weathering forces was the accumulation of a silty wind-blown material on top of the drift. This wind-blown material is called loess. It was derived largely from the sediment deposited from the immense volumes of water flowing from the ice sheet. This water filled the drainage channels and overflowed adjacent lowlands, forming terraces. Following each flood state, the water would recede and sediment which had been deposited would be picked up by the wind and redeposited on the upland. Undoubtedly some fine material was left on the surface of the drift deposit and more accumulated as the coarser drift particles were broken down. This was blown about by the wind, collecting on the south and west sides of ridges and other obstructions. The lack of vegetation on the land following the recession of an ice sheet gave the wind much more force near the surface than it otherwise would have had.

Most of the loess in that part of the county covered only by the Illinoian glacier was deposited during the time the Iowan ice sheet was melting. The Iowan glacier advance followed the Illinoian and preceded the Wisconsin. It did not touch Macon county but furnished much sediment to the stream valleys from which it was blown across the county. This deposit in turn was partly covered by drift from the Wisconsin glacier. The melting of the Wisconsin ice sheet furnished little sediment to streams so that the loess cover over its deposit is shallow and was largely derived from weathered and fine material on the surface of the drift itself. The thickness of the loess cover overlying the Illinoian drift in the western part of the county varies from 4 to 7 feet, and averages about 5½ feet. The loess deposit on the Wisconsin drift seldom exceeds 3 feet and often is entirely absent.

SOIL DEVELOPMENT

The loess and drift deposits constitute the parent material from which the soils as we know them today have been developed by the forces of weathering. When first deposited, the physical and chemical composition of the loess is very uniform; the drift is less uniform. With the passing of time the various weath-

(d) LATE SWAMP AND BOTTOM-LAND SOILS

401 Deep peat

426 Deep brown silt loam

54 454 Mixed loam

ering forces bring about differences in both the physical and chemical composition of the material from the surface down. As these differences develop, the soil profile takes form, and layers, strata, or horizons are formed which are commonly designated as surface, subsurface, and subsoil.

In addition to these vertical differences, horizontal differences also appear so that the soil of one area differs from that of another if the environments of the two areas have been different.

The weathering forces therefore bring about the formation of soils from the original parent material. Each soil is made up of layers or horizons and the character of these layers determines the character of the soil. Thus we have developed soil individuals or soil types. These types differ each from the other either because of differences in the environment under which they were developed, as, for example, height of the water table; or because of differences in the character of the original parent material.

Oxidation, solution, and leaching are important weathering processes. In addition to these, there are others such as freezing and thawing, the action of plant roots and of animals, that have an important part in soil development.

Macon county is geologically so young that the weathering forces have not had time to develop the soils fully and as a result soils are found which are spoken of as young or immature. These soils, because of their youth, still retain a large proportion of the elements of plant food originally present in the parent material. Limestone, which is readily leached, is still present in abundance in the lower subsoil of most of the soil types, tho it has been leached from the surface and subsurface and from the upper subsoil of most of them. The youngest soils in the county are found in the bottoms. The youth, or lack of development, of these soils is explained by the fact that they are subject to frequent overflow and deposition of sediment.

SOIL GROUPS

The accompanying colored soil map, shown in two sections, gives the location and boundary of each soil type, and indicates the position of streams, roads, railroads, and towns. Table 1 gives the list of soil types, the area of each in square miles and acres and also the percentage each constitutes of the total area as recorded on the map. The soil types are arranged into groups in accordance with the geological province in which they are located, the upland soils being further separated on the basis of original vegetative cover. These groups are as follows:

Upland Prairie Soils, dark-colored and usually rich in organic matter, the organic matter having been derived from the decaying roots of the wild prairie grasses which occupied this land for thousands of years.

Upland Timber Soils, those zones along stream courses over which forests grew for a long period of time. These contain in general less organic matter than the prairie soils.

Terrace Soils, including bench lands and second bottoms formed by deposits from flooded streams overloaded with sediment, perhaps at the time of the melting of the glaciers.

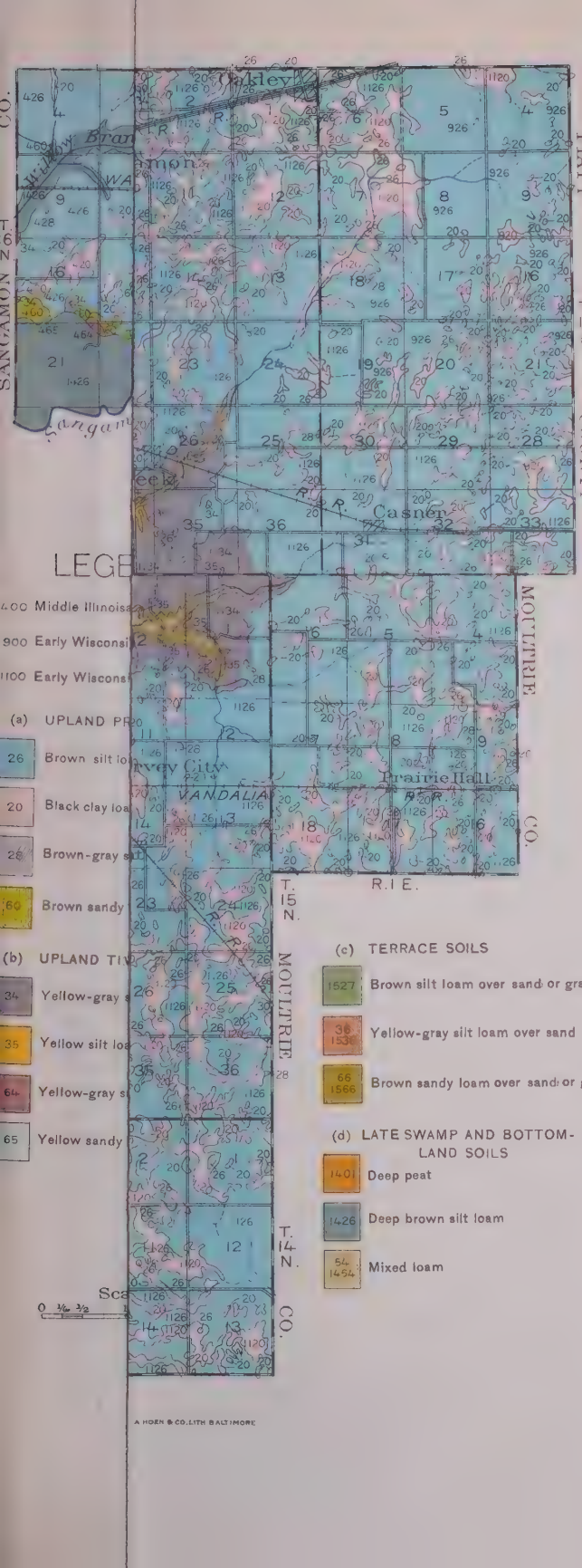
Swamp and Bottom-Land Soils, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

The soils of Macon county were surveyed and mapped during the summer of 1914. During the years which have elapsed since the map was made, continued field study and correlative laboratory work have materially increased the knowl-

TABLE 1.—SOIL TYPES OF MACON COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils (400, 900, 1100)			
426, 926, 1126	Brown Silt Loam[1]	375.91	240 582	64.71
420, 920, 1120	Black Clay Loam	107.71	68 934	18.54
428, 928, 1128	Brown-Gray Silt Loam On Tight Clay	3.56	2 278	.61
460, 960, 1160	Brown Sandy Loam	.39	250	.07
		487.57	312 044	83.93
	Upland Timber Soils (400, 900, 1100)			
434, 934, 1134	Yellow-Gray Silt Loam	45.27	28 973	7.79
435, 935, 1135	Yellow Silt Loam	20.05	12 832	3.45
465, 965, 1165	Yellow Sandy Loam	.48	307	.09
464, 964, 1164	Yellow-Gray Sandy Loam	.08	51	.02
		65.88	42 163	11.35
	Terrace Soils (1500)			
1536	Yellow-Gray Silt Loam Over Sand or Gravel	1.13	723	.18
1527	Brown Silt Loam Over Sand or Gravel	.61	390	.11
1566	Brown Sandy Loam Over Sand or Gravel	.03	19	.01
		1.77	1 132	.30
	Swamp and Bottom-Land Soils (1400)			
1454	Mixed Loam	14.31	9 158	2.46
1426	Deep Brown Silt Loam	5.70	3 648	.98
1401	Deep Peat	.04	26	.01
		20.05	12 832	3.45
	Lake	5.62	3 598	.97
	Total	580.89	371 769	100.00

[1]Including associated types described in the text but not differentiated on the map.


Tabley
Casner
VANDALIA
Prairie Hall
SANGAMON CO.
PIATT COUNTY
MOULTRIE CO.
MOULTRIE
T. 16 N.
T. 15 N.
T. 14 N.
R. 1 E.
LEGE
400 Middle Illinois
900 Early Wisconsi
1100 Early Wiscons
(a) UPLAND PR
26 Brown silt lo
20 Black clay loa
28 Brown-gray si
60 Brown sandy
(b) UPLAND TI
34 Yellow-gray s
35 Yellow silt lo
64 Yellow-gray s
65 Yellow sandy
(c) TERRACE SOILS
1527 Brown silt loam over sand or gravel
36 1536 Yellow-gray silt loam over sand or gravel
66 1566 Brown sandy loam over sand or gravel
(d) LATE SWAMP AND BOTTOM-LAND SOILS
1401 Deep peat
1426 Deep brown silt loam
54 1454 Mixed loam
Sca
0 1/16 1/2 1
A HORN & CO. LITH BALTIMORE

edge of soils, particularly with reference to classification. The use of soil characters not previously recognized has made it possible to separate soils into more definite units, each having distinct characteristics and differing from one another in agricultural value, and in treatment and fertilizer requirement. At the present time several of the types shown on the map, notably Brown Silt Loam, Black Clay Loam, and Yellow-Gray Silt Loam, would each be divided into several types having definite characteristics. An inspection of the soils of Macon county was made just prior to the publication of this report and in the following discussion these new separations, even tho not shown on the map, are described in such a way that it should not be difficult to recognize each one in the field.

For explanations concerning the classification of soils and further interpretation of the map, the reader is referred to the first part of the Appendix to this report.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN MACON COUNTY SOILS

Three Depths Represented by Soil Samples

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum, over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.
2. A middle stratum extending from 6⅔ to 20 inches, and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches, and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling we have represented separately three zones for plant feeding. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore it is the only stratum which can be greatly changed in composition as a result of adding fertilizing materials.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires to consider the information in that form. In comparing the composition of the different strata, it must be kept in mind that it is based on different quantities of soil, as indicated above. The figures for the middle and lower strata must therefore be divided by two and three respectively before being compared with each other or with the figures for the upper stratum.

Wide Range in Organic Matter and Nitrogen

It can be readily seen from Table 2 that there is a wide variation among the different soil types of Macon county with respect to their content of the different plant-food elements in the upper 6⅔ inches of soil. The most striking relationship among these variations is observed with respect to organic carbon and nitrogen, the quantities of which run parallel from type to type tho the organic-carbon content is usually 10 to 12 times as great as the nitrogen. This relationship between organic carbon and nitrogen is explained by the well-established facts that all soil organic matter (of which organic carbon is the measure) contains nitrogen, and that most of the soil nitrogen—usually 98 percent or more—is present in a state of organic combination, that is, as a part of the organic matter.

The upland prairie soils of Macon county are, for the most part, relatively high in organic matter and nitrogen, while the upland timber soils are fairly low, there being no overlapping in the two groups with respect to these constituents. This difference is noticeable, not only in the surface soil, but in the middle and lower strata as well. In addition to the upland timber types, Brown Sandy Loam as found both in the upland prairie group and on the terrace is noticeably low in its content of organic carbon and nitrogen. Sandy soils, owing to their porous character, permit the rapid oxidation of organic matter, so that its accumulation is more difficult than in heavier soils.

All of the soils of the county diminish rapidly in their content of both organic matter and nitrogen with increasing depth. This diminution is noticeable in the second stratum, 6⅔ to 20 inches, and is very pronounced in the lower stratum, 20 to 40 inches.

Phosphorus Lower in Light-Colored Soils

The total phosphorus content varies somewhat from type to type. As with organic matter and nitrogen, it is noticeably low in the light-colored upland timber soils and in Brown Sandy Loam. The least amount, 540 pounds per acre, occurs in Yellow Sandy Loam, the type which is also lowest in nitrogen and organic carbon, while the greatest amount of phosphorus, 1,640 pounds per acre, is found in Black Clay Loam, the type which shows the largest amounts of nitrogen and organic carbon. There is a tendency for the phosphorus content of soils to parallel the organic carbon to some extent, but not closely as does nitrogen. Phosphorus, in contrast with some other elements, is not appreciably removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in plant residues at the expense of underlying strata. Investigations at the Illinois Station have shown that in Brown Silt Loam, for example, about 33 percent of the total phosphorus of the surface soil is organic, and in Black Clay Loam about 37 percent. It is the second stratum which furnishes most of the phosphorus thus moved upward. Consequently, the phosphorus percentage is generally higher in the surface soil than in the second stratum, and frequently higher than in the lower stratum. It is the upland timber soils, which do not accumulate much organic matter in the surface stratum, that constitute the chief exceptions to this general trend.

Sulfur Generally Well Supplied

Sulfur, another element used by growing plants, is likewise associated to some degree with organic carbon. This is because a considerable tho varying proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of organic matter. The soils of Macon county contain from less than one-half to about three-fourths as much sulfur as phosphorus, the amount in the surface soil ranging from 270 to 1,080 pounds per acre. Like phosphorus, the sulfur content generally decreases with depth, partly because a portion of the sulfur is organic, and organic matter decreases with depth, and partly because organic sulfur is less subject to leaching than calcium sulfate (gypsum), the chief inorganic form found in soils.

The quantity of sulfur available to crops is determined not only by the soil supply, but also by the amount brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption, the amount of sulfur thus added to the soil is relatively large. At Urbana during the eight-year period from 1917 to 1924 there was added to the soil by the rainfall an average of 3.5 pounds of sulfur an acre a month. Similar observations have been made in other localities for shorter periods. The precipitation at various points in the state in a single month is found to vary from a minimum of ¾ of a pound to more than 10 pounds an acre.

These figures afford some idea of the amounts of sulfur added by rain, and also of the wide variations in amount under different conditions. Considering the amounts which are brought down in rainfall in addition to the soil supply, the facts would indicate that apparently there is little or no need for sulfur fertilizers in Macon county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started on a number of experiment fields in various parts of the state.

Potassium Content Comparatively Uniform

The potassium content of Macon county soils shows relatively less variation from type to type than any other element studied. The average amount in the surface soil is approximately 32,000 pounds an acre, and the entire range thru all the types in the county is from a minimum of 24,140 pounds up to 37,660 pounds per acre. The potassium concentration in the soil at different depths likewise shows very little variation.

Wide Variations in Calcium and Magnesium

Soils generally exhibit wide variations in calcium and magnesium content, and this is found to be the case in Macon county. In the surface soil magnesium varies from a minimum of 2,860 pounds per acre in Yellow Sandy Loam to 15,250 pounds in Black Clay Loam. This latter type also contains the highest amount of calcium found in the county, namely, 22,330 pounds an acre, while the minimum, 5,120 pounds an acre, occurs in Brown Sandy Loam, Terrace.

Aside from the calcium which may be in solution in the soil water, soil calcium exists primarily in three forms. *Calcium-aluminum silicates* are complex soil minerals which decompose but slowly and furnish but scant amounts of soluble calcium for plant growth. This is the form which predominates in most soils, particularly those which are highly acid. Calcium may be deficient as a plant-food element in such soils, so that the supplying of this element may be one of the benefits of liming. Calcium also occurs in association with the soil colloids (the finest of the clay particles), where it is absorbed; this is known as *replaceable calcium*, and is much more easily obtainable by growing plants than the mineral form above mentioned. It is found more abundantly in the soils which are non-acid or only slightly acid. Types are occasionally found that grow sweet clover luxuriantly because of the abundance of replaceable calcium which they contain, even tho they may be distinctly acid. *Calcium carbonate*, the form contained in limestone, is the third form of calcium in soils. It occurs only in alkaline (sweet) soils. Black Clay Loam in Macon county usually carries calcium carbonate in all three strata. This is indicated by the high calcium content shown in Tables 2, 3, and 4, which, it will be noted, becomes increasingly greater in passing from the upper to the lower stratum. This downward movement of dissolved calcium carbonate in the soil water is a result of leaching and accounts for its greater concentration at lower depths. Some increase in total magnesium accompanies the high calcium of these carbonate-containing strata. The increases are not great, however, because of the inability of magnesium to exist long in the soil in the form of carbonate. The carbonate of carbonate-containing soils is chiefly calcium carbonate.

In the upland soils variations in the amounts of calcium and magnesium at the different depths give some indication of the relative movement of these elements in soil formation. In the surface soil the calcium usually exceeds the magnesium in amount, as a result of the preponderance of calcium in the soil-forming materials. As these two bases are carried downward in solution, magnesium is more readily absorbed than calcium by the soil colloids, so that with increasing depth there is an increasing proportion of magnesium to calcium. This change is more pronounced in the mature soils such as Brown-Gray Silt Loam On Tight Clay, where the ratios of magnesium to calcium in the upper, middle, and lower strata, are, respectively, .76, .94, and 1.48. That is, in the surface soil there is only about three-fourths as much magnesium as calcium. In the second stratum these two elements are about equal, while in the lower stratum there is about one and one-half times as much magnesium as calcium. In youthful soils, where the leaching has been less intense or less prolonged, the ratio of magnesium to calcium shows little or no increase in the lower levels. For instance, in Black Clay Loam the ratios of magnesium to calcium are, in the three respective strata, .69, .74, and .56. Here the drop in the *relative* amount of magnesium in the lower stratum is an expression of the calcium carbonate accumulation noted above. It is worth while to note that the two sandy types in this county show neither an appreciable increase in the amount of calcium or magnesium with increasing depth, nor a change in the

ratio of these elements to each other. These soils contain so little colloidal material that they have but little ability to absorb these bases as they are carried downward by percolating water.

From these observations, it is obvious that at least some of the various processes involved in soil development are definitely reflected in the chemical properties of the soil itself. These, in turn, may be related to agricultural utilization and fertility requirements.

Local Tests for Soil Acidity Often Required

It is impracticable to attempt to obtain an average quantitative measure of the calcium-carbonate content or the acidity of a given soil type because, while some samples will contain large amounts of calcium carbonate (as in some subsoils of Macon county), others will contain none, but on the other hand, may have a lime-requirement due to the soil acidity. We thus have what may be considered positive and negative values ranging, perhaps widely, on the opposite sides of the zero or neutral point. The numerical average of such values could have no significance whatever, since such an average would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types.

The qualitative field tests made during the process of the soil survey are much more numerous than the chemical analyses made in the laboratory, and do give a general idea of the predominating condition in the various types as to acidity or alkalinity. These tests, therefore, furnish the basis for some general recommendations which are given in the descriptions of individual types on pages 21 to 29. To have a sound basis for the application of limestone the owner or operator of a farm will usually find it desirable to determine individually the lime requirements of his different fields. The section in the Appendix dealing with the application of limestone (page 38) is pertinent and should be read in this connection.

Supplies of Elements Not Proportional to Crop Removal

In the foregoing discussion we have considered mainly the amounts of the plant-food elements in the surface 6⅔ inches of soil, and rather briefly the relative amounts in the two lower strata. We have noted that some of the elements of plant food exhibit no consistent change in amount with increasing depth. Other elements show more or less marked variation at the different levels, the trend of these variations serving in some cases as clues to the relative maturity of different soil types and the processes involved in their development.

By adding together the figures for all three strata for a given type, we have an approximate invoice of the total plant-food elements within the feeding range of most of our field crops, since the major portion of their feeding range is included in the upper 40 inches. One of the most striking facts brought out of this consideration of the data is the great variation within a given soil type in the relative abundance of the various elements present as compared with the amounts removed by crops. In one of the important types in the county, Brown

Silt Loam, Upland, we find that the total quantity of nitrogen to a depth of 40 inches is 14,190 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus is approximately one-third as much, or 4,480 pounds, but this amount is equivalent to the phosphorus in nearly twice as much corn, namely, 26,350 bushels. In the surface stratum, however, which is the zone of most intensive crop feeding, we find the relative amounts of nitrogen and phosphorus more nearly in accord with the rate of removal of these elements by crops. Here the nitrogen is equivalent to 4,200 bushels of corn, and the phosphorus to 5,500 bushels.

TABLE 2.—MACON COUNTY SOILS: PLANT-FOOD ELEMENTS IN UPPER SAMPLING STRATUM, ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
Upland Prairie Soils (400, 900, 1100)								
426, 926, 1126	Brown Silt Loam	51 180	4 200	940	690	35 209	7 190	9 890
420, 1120	Black Clay Loam	67 100	7 300	1 640	1 080	33 770	15 250	22 330
428	Brown-Gray Silt Loam On Tight Clay	38 430	3 370	1 060	670	33 510	5 210	6 840
460	Brown Sandy Loam	22 360	1 500	600	320	26 540	3 580	6 180
Upland Timber Soils (900, 1100)								
934, 1134	Yellow-Gray Silt Loam	20 630	1 770	660	500	35 730	4 830	7 330
935, 1135	Yellow Silt Loam	21 350	1 900	690	270	33 870	5 940	7 180
964, 1164	Yellow-Gray Sandy Loam[1]	.....	.....	.....	.....	.....	.....	.....
965	Yellow Sandy Loam	17 800	1 400	540	380	27 580	2 860	6 560
Terrace Soils (1500)								
1527	Brown Silt Loam Over Gravel	42 080	4 020	960	860	36 000	6 500	7 040
1536	Yellow-Gray Silt Loam Over Gravel	31 720	2 480	1 060	420	37 660	5 020	8 320
1566	Brown Sandy Loam	24 040	1 800	720	440	24 140	4 100	5 120
Swamp and Bottom-Land Soils (1400)								
1401	Deep Peat[1]	.....	.....	.....	.....	.....	.....	.....
1426	Brown Silt Loam	43 160	3 600	1 240	520	31 580	7 620	10 960
1454	Mixed Loam[2]	.....	.....	.....	.....	.....	.....	.....

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]No samples were collected representing Yellow-Gray Sandy Loam and Deep Peat because of the limited area in the county occupied by these types. See pages 27 and 29.

[2]The results of chemical analyses of Mixed Loam are not included on account of the heterogeneous character of this type.

Other types show marked contrast to Brown Silt Loam, just discussed, with respect to their content of the various plant-food elements in relation to rate of removal by crops. However, in most soils, except those which are peaty, total phosphorus is more abundant than total nitrogen when considered in terms of crop equivalents rather than the actual number of pounds an acre of the respective elements.

Service of Chemical Investigations in Soil Improvement

The foregoing discussion should not be taken to mean that it is possible to predict how long any certain soil could be cropped under a given system before it would become exhausted. Nor do the figures alone indicate the immediate procedure to be followed in the improvement of a soil. It must be kept in mind that the *amount* of plant food shown to be present is not the sole measure of

TABLE 3.—MACON COUNTY SOILS: PLANT-FOOD ELEMENTS IN MIDDLE SAMPLING STRATUM, ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (400, 900, 1100)							
426, 926, 1126	Brown Silt Loam	66 880	5 920	1 560	1 100	70 980	17 920	19 030
420, 1120	Black Clay Loam	72 900	6 830	2 600	1 410	68 050	31 500	42 420
428	Brown-Gray Silt Loam On Tight Clay	38 400	3 140	1 420	720	71 880	12 460	13 240
460	Brown Sandy Loam	24 000	1 650	1 200	680	54 360	8 200	10 360
	Upland Timber Soils (900, 1100)							
934, 1134	Yellow-Gray Silt Loam	16 430	1 920	1 330	730	73 560	22 770	17 120
935, 1135	Yellow Silt Loam	18 980	1 860	1 540	420	80 000	18 300	13 220
964, 1164	Yellow-Gray Sandy Loam[1]	.....	.....	.....	.....	.....	.....	.....
965	Yellow Sandy Loam	20 920	1 520	1 240	440	56 440	6 520	13 120
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	59 720	5 320	1 640	1 200	73 520	15 520	14 120
1536	Yellow-Gray Silt Loam Over Gravel	23 480	2 320	1 800	920	79 040	14 720	14 600
1566	Brown Sandy Loam	44 520	3 400	1 480	920	50 720	10 040	11 120
	Swamp and Bottom-Land Soils (1400)							
1401	Deep Peat[1]	.....	.....	.....	.....	.....	.....	.....
1426	Brown Silt Loam	54 280	4 680	1 720	760	49 680	13 520	18 960
1454	Mixed Loam[2]	.....	.....	.....	.....	.....	.....	.....

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]No samples were collected representing Yellow-Gray Sandy Loam and Deep Peat on account of the limited area in the county occupied by these types. See pages 27 and 29.

[2]The results of chemical analyses of Mixed Loam are not included because of the heterogeneous character of this type.

the ability of a soil to produce crops. The *rate* at which these elements are liberated from insoluble forms and converted to forms that can be used by growing plants is a matter of at least equal importance (as explained on page 36) and is not necessarily proportional to the total stocks present. One must know, therefore, how to cope with the peculiarities of a given soil type if he is to secure the full benefit from its stores of the plant-food elements. In addition there are always economic factors that must be taken into consideration, since it is necessary for the farmer to decide at how high a level of productive capacity he can best afford to maintain his soil.

The chemical investigations carried out in connection with the soil survey, of which the analyses here reported are a part, are of value chiefly in two ways. In the first place, they reveal at once outstanding deficiencies or other chemical

TABLE 4.—MACON COUNTY SOILS: PLANT-FOOD ELEMENTS IN LOWER SAMPLING STRATUM, ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
Upland Prairie Soils (400, 900, 1100)								
426, 926, 1126	Brown Silt Loam	45 360	4 070	1 980	1 060	111 010	41 800	35 400
420, 1120	Black Clay Loam	49 090	3 840	3 020	1 150	101 570	66 140	118 510
428	Brown-Gray Silt Loam On Tight Clay	30 390	3 390	2 460	450	108 390	34 260	23 070
460	Brown Sandy Loam	23 820	1 600	1 440	540	76 080	9 120	15 720
Upland Timber Soils (900, 1100)								
934, 1134	Yellow-Gray Silt Loam	17 000	2 300	2 300	900	114 560	38 220	24 540
935, 1135	Yellow Silt Loam	20 160	2 280	2 610	390	117 750	36 690	20 820
964, 1164	Yellow-Gray Sandy Loam[1]	.....	.....	.....	.....	.....	.....	.....
965	Yellow Sandy Loam	20 640	1 320	1 620	300	71 820	10 260	20 100
Terrace Soils (1500)								
1527	Brown Silt Loam Over Gravel	41 100	4 020	2 160	1 380	110 100	31 440	19 740
1536	Yellow-Gray Silt Loam Over Gravel	19 260	2 400	3 120	720	116 820	34 320	25 380
1566	Brown Sandy Loam	40 260	2 580	1 560	1 200	75 360	17 160	15 840
Swamp and Bottom-Land Soils (1400)								
1401	Deep Peat[1]	.....	.....	.....	.....	.....	.....	.....
1426	Brown Silt Loam	37 500	3 300	1 980	840	92 160	21 420	24 300
1454	Mixed Loam[2]	.....	.....	.....	.....	.....	.....	.....

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]No samples were collected representing Yellow-Gray Sandy Loam and Deep Peat on account of the limited area in the county occupied by these types. See pages 27 and 29.

[2]Results of chemical analyses for Mixed Loam are not included on account of the heterogeneous character of this type.

characteristics which alone would affect soil productivity to a marked extent, or point the way to corrective measures. It should be borne in mind, however, that fairly wide departures from the usual composition are necessary before the chemical analysis alone can be followed as a guide in practice without supplementary information from other sources. It is probable that the results of chemical soil analyses are frequently misused by attempting to interpret small differences in the amount of a certain plant-food element as indicative of similar differences in the fertilizer need. For example, differences of 100 or 200 pounds of phosphorus per acre in soils containing 1,000 pounds or thereabout in the surface soil should not be considered as indicating a corresponding difference in response to phosphate fertilization. Again, 100 pounds to the acre of active nitrogen added by plowing down a clover crop may be of more importance to the succeeding crop than a difference in soil composition of 1,000 pounds an acre of nitrogen. An example of the direct use of the results of chemical investigations is the marked shortage of potassium in peat soils associated with the need for potassium fertilizers; another case is the determination of the lime need of soils by chemical tests.

The second use of chemical methods is in the more detailed study of soils. The processes of soil development leave their imprint upon the soil both in its physical conformation and also in its chemical characteristics. Likewise every operation in the handling of the soil and every application of fertilizer or liming material disturbs its equilibrium, setting up new reactions, which are in turn reflected in variations in crop adaptability, producing capacity, and agricultural usefulness. Chemistry is a most important tool in tracing and characterizing such changes, and chemical investigations are undertaken with the aim of aiding in the classification of soils as well as making possible more accurate prediction of their agricultural value and fertility needs, and response to different methods of management.

DESCRIPTION OF SOIL TYPES

UPLAND PRAIRIE SOILS

The upland prairie soils of Macon county occupy 487.57 square miles, more than four-fifths of the total area of the county. These soils are brown to black in color. There is, however, considerable difference in the color, not only of the various types, but within types, particularly in the case of Brown Silt Loam. The character of the subsoil is also notably different, varying from a loose, open, well-drained silt loam to a compact, sticky, and slowly pervious clay. The dark color of the prairie soils is due to an accumulation of organic matter from the fibrous roots of the prairie grasses that grew for centuries on this land prior to its cultivation by man. A covering of fine soil and a mat of vegetative material, by partially excluding the oxygen, protected these roots from rapid and complete decay. From time to time the mat of old grass stems and leaves was partially destroyed by prairie fires and decay, but it was constantly being renewed, and while it added little organic matter to the soil directly, it served to retard the decay of the roots of the grasses.

Brown Silt Loam (426, 926, 1126)

Brown Silt Loam, as mapped in Macon county, occupies 375.91 square miles, about two-thirds of the total area of the county. It varies in character depending on topography and in the kind of mineral material from which it has been derived, and it would now be separated into at least four distinct types. Each of these is described below so that it may be recognized in the field.

1. **Light Brown Silt Loam.** This type occurs on the higher, rolling areas where surface drainage is good. It is limited to the knolls in the southwestern part of the county and to that outer portion of the Shelbyville moraine from which erosion has not removed the silty deposit. Occasionally small areas are found on the rolling land near stream valleys. It covers only a very small percent of the total area of the county. The surface soil is about 6 inches thick and is a light brown or yellowish brown silt loam. The subsurface, extending to a depth of 15 inches, is a loose, yellowish brown silt loam. The upper subsoil is an open, dark reddish yellow, silty clay loam. The lower subsoil which is found at depths of 25 to 30 inches is a very open, grayish yellow, silt loam. The soil is very well drained.

Management.—The surface slope of this type of soil is such that sheet erosion is active. Care must be exercised to prevent washing either by keeping a cover of vegetation or by terracing. The soil is not high in organic matter and nitrogen and it is medium acid. Limestone should be applied at the rate of 2 to 3 tons an acre, and clover grown and turned under every three or four years as a source of organic matter and nitrogen. As this type usually occurs in small areas, it makes an excellent location for alfalfa. After liming it is especially suited to the growing of alfalfa and other legumes. The best information available on the treatment of this type comes from the Mt. Morris and Dixon experiment fields which are located in part on Light Brown Silt Loam. The results from these fields show a very marked response to manure. Limestone in addition to manure has given a further increase sufficiently large to pay a good profit on the cost of the limestone. Limestone with residues has been another profitable treatment. Neither potash nor rock phosphate applications have increased yields sufficiently to be profitable on this soil type. The reader is referred to the summarized yields on the Mt. Morris and Dixon fields found on pages 49 to 53 of this report.

2. **Brown Silt Loam.** This type occupies intermediate topographic positions and is by far the most extensive type in the county. It is rather uniformly distributed but is not so prevalent near main stream courses or in very flat areas as elsewhere. The surface soil is about 8 inches thick and has a dark brown color. The subsurface is a somewhat lighter brown than the surface. The subsoil begins at 18 inches and is a brownish yellow, somewhat compact, clay loam. The lower subsoil is friable and yellowish and begins at about 30 to 34 inches.

Management.—This type of soil drains well and is not subject to severe erosion. It was originally well supplied with organic matter but continued cropping has reduced the supply considerably. The soil is acid and requires at least 2, and possibly 2½, tons an acre of limestone to grow alfalfa, sweet clover,

or the best red clover. The Kewanee experiment field is located, for the most part, on this soil type. Unfortunately, the Kewanee field has several draws crossing the plots which are a much heavier soil, so that the results from the field cannot be applied to Brown Silt Loam with as much confidence as would otherwise be the case. It is, however, almost certainly true that the presence of the heavier soil on the Kewanee field has the effect of diminishing the increases due to treatment. This field shows very good results for manure on corn and oats, but less effect on wheat. Limestone gives a more profitable return used in the residues system than with manure, but in each case the increases were satisfactory. Rock phosphate has produced a profitable return in the residues system but has failed to pay for its cost in the manure system. The Bloomington field, which is located in part on this same soil type, has responded very markedly to the application of phosphates. The suggestion therefore is that if manure is not available, one of the phosphates be applied for wheat after the nitrogen needs are met by the growing of legumes. Summarized results from the Kewanee and Bloomington fields are given in the Supplement to this report on pages 53 to 59.

3. Brown Silt Loam On Clay. This type occupies the nearly level or very gently sloping areas and is largely confined to the northwestern, southwestern, and southeastern parts of the county. It is closely associated with Black Clay Loam but lies on higher ground and has a more sloping surface. It is not extensively developed even in these flat areas. The surface soil is a dark brown silt loam, 10 inches thick. The subsurface is similar to the surface in color but heavier in texture, usually a heavy, silty clay loam. The upper subsoil begins at 18 to 20 inches and is a brownish yellow, compact, plastic clay loam. The lower subsoil, beginning at 36 inches or deeper, is a silty clay loam, yellow in color, and spotted with reddish brown. It is more friable than the upper subsoil.

Management.—The lack of sufficient surface slope and the compact plastic subsoil of this type makes artificial drainage necessary. Tile will draw well and if a proper outlet is maintained, the soil can be adequately drained by tiling. This type is only slightly acid. It will grow red clover without lime but 1½ to 2 tons an acre of limestone is necessary to insure alfalfa or sweet clover stands. Unless these two legume crops are to be grown, the use of limestone could hardly be advised. The Aledo experiment field most nearly represents this soil type and the results from this field may be used as a guide in its treatment. (See page 59). Rock phosphate has not caused significant increases in yield on the manure plots. On the residues plots some increase in yield has followed its use but the increases have not been sufficiently large to justify advising its use. Comparisons of phosphorus carriers are being made on the Aledo field. The results show that acid phosphate, bone meal, and slag phosphate all rank slightly ahead of rock phosphate on this soil. It is suggested that a trial application of one of the phosphate fertilizers be made before using phosphate in a large way.

4. Brown Silt Loam On Drift. This type occupies the sloping areas on the knolls and ridges and near small stream courses from which erosion has removed some of the silty surface material. It is not extensive and occurs principally on the Shelbyville and Cerro Gordo moraines. The surface soil is about

7 inches thick and light brown in color. The subsurface is thin and is yellowish brown in color. The upper subsoil is slightly compact, is brownish yellow in color, and is often sandy or gravelly. The lower subsoil is yellow and is a mixture of sand, gravel, and clay. Where erosion is active, the gravelly subsoil is near enough to the surface to make the soil drouthy during dry seasons. The calcareous drift is usually 40 to 45 inches below the surface but in the eroded areas it is often as shallow as 25 inches.

Management.—Protection from erosion as suggested for Light Brown Silt Loam is also suggested for this type. The surface soil is medium acid, but as the sweet subsoil is nearer the surface in this type, an application of 2 tons of limestone is all that is required for a successful stand of sweet clover or alfalfa. Red clover will grow without lime but some lime is needed for a good stand. There is no experiment field located on this soil type but from its nature and the results of yields on associated soil types, it is suggested that a trial of the phosphates be made, as some of them may prove profitable. One of the potash salts might also be beneficial if applied on corn and it is suggested that this be first tried experimentally before applying to large fields. Potash salts should be applied at the rate of about 75 pounds an acre to the corn crop.

Black Clay Loam (420, 920, 1120)

Black Clay Loam, as mapped in Macon county, occupies 107.71 square miles, or about one-fifth of the total area of the county. This type includes at least three distinct types as it would now be mapped. These types cannot be so easily recognized in the field as those of the silt loam group just described, because there is little or no difference in their topographic occurrence. Their chief differences are in the character of the subsoil and lime content. No attempt will be made to describe each type individually, but in this general discussion the pronounced characteristics of each will be brought out. The surface soil is 9 to 12 inches thick and is a black clay loam. This is characteristic of all these types. The subsurface is 8 to 10 inches thick and ranges in color from a drabbish black to a brownish black with yellow spots. It is heavier than the surface soil but seldom compact. The upper subsoil varies considerably. In most of the small areas in the northeastern part of the county, the upper subsoil is grayish drab clay to about 32 inches; below that it becomes drabbish gray, a typical joint clay. In the flat area in the southeastern part of the county, the upper subsoil is a brownish drab clay, slightly compacted, and contains some gravel. The lower subsoil is more gravelly and is mottled with yellow. In the western part of the county the upper subsoil is brownish drab mottled with yellow, compact, and plastic. The lower subsoil is a drabbish yellow clay loam. The first two subsoils described are occasionally calcareous, and in places even the corresponding surface soils are calcareous.

Management.—When properly drained Black Clay Loam is a productive soil. The soil should be well tiled and sufficiently large outlets provided. It rarely needs limestone to grow sweet clover, and then only a small amount. Some of the calcareous areas above described contain sufficient alkali to be harmful. Unthrifty growth in these areas indicates the need of potash. This type of soil

should receive regular additions of organic matter to maintain a favorable physical condition. Both stable manure and green manures should be used for this purpose. Clover should be grown every third or fourth year. The reader is referred to the summarized results of the Hartsburg experiment field which are found in the Supplement to this report, pages 64 and 65. The soil on this field is similar to Black Clay Loam as it occurs in Macon county.

Brown-Gray Silt Loam On Tight Clay (428, 928, 1128)

Brown-Gray Silt Loam On Tight Clay occurs in the northwestern part of the county and south of the town of Macon. It occupies a total of only 3.56 square miles in Macon county.

The surface soil is 6 to 7 inches thick and has a grayish brown color when dry, but may entirely lose the gray cast when moist. The thickness of the subsurface is variable, ranging between 12 and 18 inches. Its color is brownish gray to gray, and it sometimes has an ashy feel. Immediately below the gray subsurface is the plastic, compact, yellowish gray clay layer, the upper subsoil. This layer is 8 to 15 inches thick, and is almost impervious to water. Occasionally this tight layer is absent and the gray, ashy material continues down to a depth of 40 inches. The lower subsoil begins at depths of 36 to 42 inches and is a grayish yellow, friable silt loam. Numerous small, brownish-black, rounded iron pellets are found both on the surface and thru the soil. Small areas occur within the type in which large gray pellets or concretions of lime are found at or near the surface.

Management.—Drainage is one of the difficulties encountered in the management of this type. Surplus water must be removed by surface ditches and open furrows, as the tight subsoil makes tile ineffective except on those areas where the gray, ashy material extends down to a depth of 2½ feet or more. The soil is acid except in those areas in which lime concretions are found. Each field should be tested in detail with the assistance of the county farm adviser or the Agricultural Experiment Station before applying limestone, as this soil type varies from 0 to 3 or 4 tons in lime requirement per acre. The growing and plowing under of legume crops, especially sweet clover, and the addition of animal manure very materially improve the grain crops which follow. If satisfactory yields are not obtained after this procedure, a trial application of 75 pounds of some potassium fertilizer might be made. There is no experimental evidence to back up this recommendation so that only a trial should be made before fertilizing the entire field.

Brown Sandy Loam (460, 960, 1160)

Brown Sandy Loam is a very minor type in Macon county. It occurs principally as small areas adjacent to the Sangamon river valley in the western part of the county and occupies only 250 acres. Its topography and texture suggest that its material was blown up from the river bottom. The surface soil, to a depth of 6 to 7 inches, is a brown sandy loam. The subsurface is more sandy and is yellowish in color. The upper subsoil is a yellow sandy loam, slightly

compact, enough so to keep the soil from being drouthy. The lower subsoil is a loose yellow sand.

Management.—The occurrence of this type in small areas within larger areas of Brown Silt Loam which have an intermediate topographic position makes it difficult to give it special treatment. It is recommended that this type be treated similarly to Brown Silt Loam except that special emphasis be given to increasing the organic-matter content by adding manure and by growing and plowing under green manures. The lime requirement is variable and the land should be tested before lime is applied.

UPLAND TIMBER SOILS

The upland timber soils are confined to narrow belts adjacent to the main streams, principally Sangamon river. They cover 65.88 square miles, slightly more than one-tenth of the total area of the county. The timber soils are characterized by a yellow or yellowish gray color which is due to their low organic-matter content. This lack of organic matter has been caused by the long-continued growth of forest trees. As the forests invaded the prairies, the following effects were produced: the shading of the trees prevented the growth of grasses, the roots of which are mainly responsible for the large amount of organic matter in the prairie soils; and the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed or were destroyed by forest fires.

Yellow-Gray Silt Loam (434, 934, 1134)

Yellow-Gray Silt Loam as mapped occupies 45.27 square miles, forming the outer light-colored soil belt along streams. The character of the type varies with changes in topography and in the soil material from which it was formed. By far the larger portion is rather uniform and is described as follows. The surface soil is a brownish yellow silt loam about 6 inches thick. The subsurface is a grayish yellow silt loam about 9 to 12 inches thick. The upper subsoil begins at 15 to 18 inches and is a compact, slightly plastic, pale yellow clay loam, mottled with gray. On the more rolling areas it is less compact and more reddish. On the flatter areas it is more compact and grayish. The lower subsoil, below 32 to 36 inches, is a pale yellow silt loam, mottled with gray.

A few small areas south of the town of Antioch mapped as Yellow-Gray Silt Loam are rather flat. The surface soil in these flat areas is brownish gray and the subsurface is ashy gray. The upper subsoil is drabbish gray and very compact. In areas near streams where erosion has removed some of the silty covering, the gravelly drift forms the subsoil. These latter areas are not extensive since, when erosion starts, it soon removes all the loess covering and makes the area rough and hilly.

Management.—In the management of Yellow-Gray Silt Loam attention must be given to the topography on which it occurs as described above. The rolling areas have a pervious subsoil but are subject to erosion. Care should be taken to have vegetation growing on this land as much of the time as possible. There is little danger of erosion on the more gentle slopes but attention must be given

to underdrainage, particularly to the flat areas whose subsoil is almost impervious. Surface ditching must be resorted to in these flat areas to remove the excess surface water. The type as a whole is acid but varies considerably in the amount of lime required to grow clovers. In general, 3 to 4 tons of limestone per acre must be spread before a satisfactory sweet clover or alfalfa stand can be obtained. The organic-matter content of this soil should be built up by the addition of animal and green manures plowed down. Altho there are no experiment field results on which to base fertilizer recommendations for this type of soil, it is suggested that a trial be made of one of the phosphates for wheat following the addition of organic matter.

Yellow Silt Loam (435, 935, 1135)

Yellow Silt Loam occupies 20.05 square miles and is found as the inner, light-colored soil belt along Sangamon river and its larger tributaries. It is a type produced by erosion and is rough and hilly. The character of the soil depends on the rapidity of the erosion; in protected places from which the timber has not been removed it resembles that of Yellow-Gray Silt Loam, and from this condition it varies thru all stages to one in which there is an entire absence of soil development. On these areas the sandy gravelly drift forms the surface. In other places the soil is shallow and friable and of a yellow or grayish yellow color.

Management.—Yellow Silt Loam should not be cultivated except where the slopes are not great and when proper attention can be given to controlling erosion. The less gullied areas can be used for permanent pasture or orchards while the remainder can be most profitably kept in permanent timber. Following an application of 1½ to 2 tons of limestone, sweet clover or alfalfa can be seeded on the less steep slopes. Alfalfa preceded by sweet clover usually makes a good stand and will remain on the land a number of years. An account of experiments in reclaiming badly eroded land of this soil type is given in the Supplement, page 65, under the Vienna field.

Yellow Sandy Loam (465, 965, 1165)

Yellow Sandy Loam is associated with Yellow Silt Loam and differs from it only in having received a coarse, sandy, wind-blown deposit from the adjacent bottom land. It occurs along Sangamon river and occupies only 307 acres in the county. The less sloping parts of it are well suited for alfalfa following liming.

Yellow-Gray Sandy Loam (464, 964, 1164)

Yellow-Gray Sandy Loam is a very minor type in Macon county, totaling only 51 acres. It is found in small areas near the Sangamon river bottom land. It is similar to Brown Sandy Loam excepting that it is lighter in color and is more acid. It may be handled in much the same manner, tho it requires more organic matter.

TERRACE SOILS

The terrace formations were made in remote times by overloaded and flooded streams which deposited an immense amount of material in the old channels. Later, as the streams diminished in size and cut their channels deeper, new bottom lands were developed, leaving the old flood plains above overflow, thus forming terraces. The terraces in Macon county were formed during or shortly after the advance of the Wisconsin glacier. They were later covered with a shallow deposit of wind-blown material similar to that of the uplands. All the terraces occur along Sangamon river. They occupy only 1.77 square miles.

Yellow-Gray Silt Loam Over Sand or Gravel (1536)

Yellow-Gray Silt Loam Over Sand or Gravel occupies 1.13 square miles and is found occurring in small areas between the upland and bottom land along Sangamon river. It differs little from Yellow-Gray Silt Loam, Upland, except in being somewhat better drained. See page 26 for a description of that type and for suggestions regarding its management.

Brown Silt Loam Over Sand or Gravel (1527)

Brown Silt Loam Over Sand or Gravel occurs along the south side of Sangamon river near the Sangamon county line. It covers only .61 square mile. The character of the soil resembles that of the second type described under Brown Silt Loam, Upland, except that it is more sandy. See page 22 for a description of that type and for suggestions regarding its management.

Brown Sandy Loam Over Sand or Gravel (1566)

There are only 19 acres of Brown Sandy Loam Over Sand or Gravel mapped in Macon county. It occurs in the larger area of Brown Silt Loam Over Sand or Gravel. See page 25 for a description and suggestions regarding the management of Brown Sandy Loam, Upland, which is similar to this terrace type.

SWAMP AND BOTTOM-LAND SOILS

The swamp and bottom-land soils in Macon county are found along the creeks and along Sangamon river. All of these soils are subject to overflow. There is a total of 20.05 square miles of bottom land mapped in Macon county, most of which is Sangamon river bottom land.

Mixed Loam (1454)

Mixed Loam, as its name implies, is very diverse in character. It is formed from deposits made during overflows. Its surface soil varies from a clay loam to a sandy loam, but is generally a silt loam of a sandy nature. The subsurface and subsoil vary as does the surface. No soil development has taken place as the material is too young and in many places is still being buried by a shallow deposit during each overflow. There are 14.31 square miles of Mixed Loam in the county.

Management.—The diversity of Mixed Loam prevents giving very specific recommendations for management. It will usually grow clover without lime and unless the land is subject to frequent overflow clovers should be grown and turned under to add organic matter. Corn is the chief crop grown on this land, and because the soil is frequently renewed, no fertilizer applications are needed.

Deep Brown Silt Loam (1426)

There are 5.70 square miles of Deep Brown Silt Loam mapped in the Sangamon river bottom land in the west part of the county. This area is more uniform in texture of the surface soil than is the remainder of the bottom land. It is a young, immature soil, productive, easily worked, and non-acid. The surface color is dark brown which frequently extends to a depth of 15 to 18 inches; below this the soil has a drabbish cast, becoming yellow at 30 to 40 inches. On the very flat areas where water stands, a gray color has developed below 20 inches. Deep Brown Silt Loam requires the same management as Mixed Loam because it is subject to frequent overflow.

Deep Peat (1401)

An area of 26 acres, forming part of the Lake Fork bottom land in Section 11, Township 18 North, Range 1 East, was originally mapped as Deep Peat. It is now largely decomposed into a muck. It is used for pasture and until better drainage is provided, it must continue to be uncultivated.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items, such as native vegetation (whether timber or prairie), topography, and geological origin and formation, may assist in the differentiation of types, altho they are not fundamental to it.

Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following definitions are introduced:

Soil Profile. The vertical section of the soil from the surface to the underlying unweathered material is called the soil profile. In a mature soil the profile is made up of a number of distinguishable layers or horizons.

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon. For technical descriptions, soil scientists have adopted the designations *A*, *B*, and *C* for the principal horizons. Describable differences within an horizon are indicated by subscrip numbers, as A_1, A_2, B_1, B_2 and so on.

In this report the soil layers are described under the terms "surface," "subsurface," and "subsoil." The surface and subsurface are embraced in the *A* horizon—the surface corresponding to the A_1 horizon and the subsurface to those lying below the A_1. The subsoil corresponds to the *B* horizon.

For a description of the surface, subsurface, and subsoil, see page 13.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, whether level, rolling, hilly, or otherwise.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in differentiating soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil material.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made wherever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of this report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their respective index numbers are given in the following list.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoian moraines,* including the moraines of the Illinoian glaciations
300 *Lower Illinoian glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoian glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoian glaciation,* covering about fourteen counties northwest of the middle Illinoian glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoian
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation

1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* formed by material derived from the Illinoian or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the remainder of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoian glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to the last of November. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction.

FIG. 7.—EXAMINING THE SOIL PROFILE

Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development in road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 13.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of micro-organisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, crop-

ping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

At least ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are

FIG. 8.—ALL ESSENTIAL PLANT-FOOD ELEMENTS MUST BE PRESENT

The jars in which these corn plants are growing contain pure sand to which have been added various combinations of the essential plant-food elements. If a single one of these elements is omitted, the plants cannot develop; they die after the small supply stored in the seed becomes exhausted.

absorbed from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants are dependent upon the soil for the other elements, and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5. [2]Young second-year growth ready to plow under as green manure. [3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering

bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrificataion and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in

[1]Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4_1 have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

The nitrogen problem is one of foremost importance in American agriculture. There are four reasons for this: nitrogen is becoming increasingly deficient in most soils; its cost when purchased on the open market is often prohibitive; it is removed from the soil in large amounts by crops; and it is readily lost from soils by leaching. A 50-bushel crop of corn requires about 75 pounds of nitrogen for its growth; and the loss of nitrogen from soils by leaching may vary from a few pounds to over one hundred pounds an acre in a year, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about 69 million pounds of atmospheric nitrogen. Leguminous plants such as clover are able, with the aid of certain bacteria, to draw upon the inexhaustible supply of air nitrogen, utilizing it in their food requirements. In so doing these leguminous plants, thru the decay of their own

tissues, add to the soil nitrogen that has been taken from the air and transformed into food material that can be assimilated by other kinds of crops that follow.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may

FIG. 9.—LEGUMES CAN OBTAIN THEIR NITROGEN FROM THE AIR

The photograph tells the story of how clover benefits the soil. In the pot at the left all the essential plant-food elements, including nitrogen, are supplied. In the middle jar all the elements, with the single exception of nitrogen, are present. At the right nitrogen is likewise withheld but the proper bacteria are supplied which enable the clover to secure nitrogen from the air.

be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

Different soil types display great variation in phosphorus content. In Illinois soils a range from 320 to 4,900 pounds an acre has been found in the surface 6⅔ inches, depending mainly on the origin of the soil.

The removal of phosphorus by continuous cropping slowly reduces the amount of this element available for crop use unless its addition is provided for by natural means such as overflow, or by agricultural practices such as the addition of phosphatic fertilizers and the use of rotations in which deep-rooting leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different phosphorus-containing materials that are used as fertilizers. The more important of these are rock phosphate, superphosphate, bone meal, and basic slag.

Rock Phosphate.—Rock phosphate is a mineral substance found in vast deposits in certain regions. A good grade of the rock should contain 12 to 15 percent of the phosphorus element. The rock should be ground to a powder fine enough to pass thru a 100-mesh sieve, or even finer.

Superphosphate.—Superphosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. By further processing, different concentrations are produced. The most common grades of superphosphate now on the market contain respectively 7, 8¾, and 10½ percent of the element phosphorus, and even more highly concentrated products containing as high as 21 percent are to be had. In fertilizer literature the term phosphorus is usually expressed as "phosphoric acid" (P_2O_5) rather than the element phosphorus (P), and the chemical relation between the two is such as to make the above figures correspond to 16, 20, 24, and 48 percent of phosphoric acid respectively. Besides phosphorus, superphosphate also contains sulfur, which is likewise an element of plant food. In general, phosphorus in superphosphate is considered to be more readily available for absorption by plants than that of raw rock phosphate.

Bone Meal.—Prepared from the bones of animals, bone meal appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen. If the material is purchased only for the sake of the phosphorus, the cost of the nitrogen represents a useless expense. Steamed bone meal is prepared by extracting most of

the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate, containing about 10 to 12 percent of the element phosphorus and about 1 percent of the element nitrogen.

Basic Slag.—Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore tends to influence the soil reaction in the direction of reducing soil acidity.

Comparative Value of Different Forms of Phosphorus.—Obviously the carrier of phosphorus that gives the most economical returns, considered from all standpoints, is the best one to use. Altho this matter has been the subject of much discussion and investigation, the question remains unsettled. The fact probably is that there is no single carrier that will prove the most economical under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

The relative cheapness of raw rock phosphate as compared with the treated material, superphosphate, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in the form of rock than in the form of superphosphate, the ratio being, under present market conditions, roughly speaking 3½ to 1; that is to say, a dollar will purchase about three and a half times as much of the phosphorus element in the form of rock phosphate as in the form of superphosphate, and this is an important consideration if one is interested in building up a phosphorus reserve in the soil.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using superphosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, the silt loams and clay loams, are well stocked with potassium, altho it exists mainly in a very slowly soluble form. Many field experiments in various sections of Illinois during the past twenty-five years have shown little or no response to the application of potassium in the production of our common grain and hay crops. On the light-colored soils of southern Illinois, however, where stable manure has not been employed, potassium has been applied with profit, the benefit appearing mainly in the corn crop.

Peat soils are usually low in potassium content. It has frequently been demonstrated in field experiments that the difference between success and failure in raising crops on peat land depends on the use of a potash fertilizer.

Potassium has proved beneficial also on the so-called "alkali" spots occurring on certain soil types that are rather high in organic matter, including peat and very dark-colored sandy, silt, and clay loams. The potassium salts in this case appear to exert a corrective influence over what seems to be an unbalanced plant-food condition caused by an excess of nitrate in the soil.

Potassium fertilizer may be procured in the form of one of its salts, such as chlorid, sulfate, or carbonate of potassium, and any of these materials may be applied, where needed, at the rate of 50 to 150 pounds an acre, according to the method of distribution. For our most common crops about the only basis for choosing among these forms is the matter of price, taking into consideration the potassium content. Kainit is another substance containing potassium, but it is combined with magnesium in the form of a double salt. It is therefore less concentrated than the salts mentioned, and so should be applied in larger quantities. An application of about 200 pounds or more of kainit to the acre is suggested.

The Calcium and Magnesium Problem

When measured by crop removals of plant-food elements, calcium is often more limited in Illinois soils than is potassium, tho magnesium may occasionally be the low element. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks,

weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

As a general principle, straw and cornstalks should be turned under, and not burned. Corn-borer control, however, may demand unusual measures, even to the burning of the stalks. There also is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the corn is planted. Whether the crop be corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotation

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance, for every particular case, what crop rotation will prove best, because of variation in farms and farmers and in prices for produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the best adapted for building up poor soils.

On pages 46 and 47 are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)
Sixth year —Clover, or clover and grass

In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed; or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

The two following rotations are suggested as especially adapted for combating the corn borer:

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Corn (for silage)
Sixth year —Wheat (with sweet clover)

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Wheat (with alfalfa)
Sixth year —Alfalfa

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)
Fifth year —Clover

First year —Corn
Second year —Soybeans
Third year —Corn
Fourth year —Wheat (with legume)
Fifth year —Legume

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field rotating over all fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute barley or rye for the oats or wheat. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover, or it may include alfalfa used as a biennial. The mixing of alfalfa with clover seed for a legume crop is a recommendable practice. In connection with livestock production it may be desirable to mix grass with the clover for pasture or hay. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results From Experiment Fields on Soil Types Similar to Those Occurring in Macon County)

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various soil types. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on soil types described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to forty acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with each crop represented every year.

Farming Systems

On most of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system but certain modifications have been introduced in recent years, as explained in the descriptions of the respective fields.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots at the beginning was usually standardized according to a rather definite system. With advancing experience, however, new problems arose calling for new experiments, so that on most of the fields

plots have been divided and a portion given over to new systems of treatment, at the same time maintaining the original system essentially unchanged from the beginning.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—Limestone has usually been applied at the rate of 4 tons an acre as an initial application, and 2 tons an acre every four years thereafter until a considerable excess has accumulated in the soil. Rock phosphate has been applied at the rate of one ton an acre at the beginning, followed by an annual acre-rate of 500 pounds applied once in the rotation until a considerable excess has accumulated. Potassium has been applied usually in the form of 200 pounds of kainit a year. When kainit was not available, owing to conditions brought on by the World War, potassium carbonate was used.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated, (sP= superphosphate, bP= bone meal, rP= rock phosphate, slP= slag phosphate)
K = Potassium (usually in the form of kainit)
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed

THE MT. MORRIS FIELD

The soil on the Mt. Morris experiment field, in Ogle county, represents fairly well the type Light Brown Silt Loam, described on page 22, altho the plots are not altogether uniform. This field was established in 1910. The plots considered here comprize four series under a rotation of corn, oats, clover, and wheat, with soil treatments as indicated in the accompanying table. The application of straw to the residues plots has been discontinued in these later years. In 1922 the application of limestone, and in 1923 the application of rock phosphate, were indefinitely suspended in order to observe the residual effect of these materials. The total quantity of limestone, applied since the beginning of the experiments averaged 7¾ tons an acre and the total amount of rock phosphate was 4 tons an acre.

FIG. 10.—CORN ON THE MT. MORRIS FIELD

The two pictures represent the extremes in corn production on this field. Where the untreated land has produced as a sixteen-year average 43.4 bushels an acre, the land under the residues, limestone, phosphate, potash treatment has yielded 67.2 bushels. The most profitable treatment, however, has been that of residues and limestone, which has produced 62.4 bushels.

A summary of the results of the work is given in Table 7, in the form of the average annual crop yields for the years since the complete soil treatments have been in effect.

TABLE 7.—MT. MORRIS FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields, 1913-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *14 crops*	Corn *16 crops*	Oats *16 crops*	Clover[1] *13 crops*	Soybeans *2 crops*
1	0	22.1	43.9	57.3	(1.79)	(1.56)
2	M	26.6	59.0	66.9	(2.34)	(1.70)
3	ML	32.8	64.7	70.7	(2.90)	(1.80)
4	MLP	34.2	64.3	71.5	(2.84)	(1.92)
5	0	22.1	43.4	53.9	(1.52)	(1.34)
6	R	24.2	50.5	58.0	(1.57)	(1.60)
7	RL	31.7	62.4	68.1	(2.07)	(1.89)
8	RLP	34.7	65.8	69.8	(2.09)	(2.07)
9	RLPK	35.2	67.2	70.6	(2.15)	(2.00)
10	0	22.9	43.0	51.7	(1.64)	(1.68)
	Crop Increases					
	M over 0	4.5	15.1	9.6	(.55)	(.14)
	R over 0	2.1	7.1	4.1	(.05)	(.26)
	ML over M	6.2	5.7	3.8	(.56)	(.10)
	RL over R	7.5	11.9	10.1	(.50)	(.29)
	MLP over ML	1.4	− .4	.8	−(.06)	(.12)
	RLP over RL	3.0	3.4	1.7	(.02)	(.18)
	RLPK over RLP	.5	1.4	.8	(.06)	−(.07)

[1] Including some seed evaluated as hay.

The outstanding results from these records are those produced by the manure treatment. Over 15 bushels of corn, over 9 bushels of oats, 4½ bushels of wheat, and a half ton of clover have been the average annual acre increases in crop yields from the manure plots over the corresponding checks. Residues alone have also produced increases in the crop yields altho the effect is much less pronounced than that of manure alone.

Limestone has been very profitably used in both the manure and residues systems but the benefit has been greater in the residues system.

The rock phosphate, as usual, has been somewhat more effective used with residues than with manure, but under present market conditions and used in the quantity employed in these experiments, it has thus far not returned its costs, even with residues. However, as noted above, applications of phosphate have been suspended and the residual effect of the accumulated phosphorus in the soil during the years to come will be awaited with interest.

No significant effect is apparent from potassium as used in these experiments.

THE DIXON FIELD

A summary of the results from the Dixon experiment field are presented here, inasmuch as the soil of this field is similar to some of that found in Macon county. (See discussion of Light Brown Silt Loam, page 22). This field includes about 21 acres and is laid out into two general systems of plots, a major and a minor system. The results from the major system will be considered here.

TABLE 8.—DIXON FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields, 1912-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *13 crops*	Corn *17 crops*	Oats *16 crops*	Barley *1 crop*	Clover[1] *10 crops*	Soybeans *5 crops*
1	0	19.9	36.9	48.1	43.3	(1.71)	(1.50)
2	M	26.3	57.8	61.4	46.4	(2.45)	(1.75)
3	ML	30.7	60.6	65.3	55.2	(2.70)	(1.87)
4	MLP	33.8	63.0	66.9	58.3	(2.83)	(1.91)
5	0	21.4	41.7	53.0	49.5	(1.41)	(1.27)
6	R	24.3	48.9	56.4	53.8	(1.49)	(1.43)
7	RL	27.7	56.4	61.1	54.5	(1.79)	(1.40)
8	RLP	32.0	57.8	63.4	59.0	(2.04)	(1.38)
9	RLPK	33.2	61.4	64.0	56.9	(2.21)	(1.42)
10	0	19.8	40.3	50.3	45.4	(1.81)	(1.46)
	Crop Increases						
	M over 0	6.4	20.9	13.3	3.1	(.74)	(.25)
	R over 0	2.9	7.2	3.4	4.3	(.08)	(.16)
	ML over M	4.4	2.8	3.9	8.8	(.25)	(.12)
	RL over R	3.4	7.5	4.7	.7	(.30)	−(.03)
	MLP over ML	3.1	2.4	1.6	3.1	(.13)	(.04)
	RLP over RL	4.3	1.4	2.3	4.5	(.25)	−(.02)
	RLPK over RLP	1.2	3.6	.6	−2.1	(.17)	(.04)

[1] Including some seed evaluated as hay.

FIG. 11.—CLOVER ON UNTREATED LAND, DIXON FIELD

A cutting of red-clover hay obtained from an untreated plot. Compare with the crop shown in Fig. 12.

The rotation practiced has been wheat, corn, oats, and clover. The treatment of the plots and management of the crops were, for the most part, maintained up to 1922 according to the general plan described on pages 48 and 49. The most important modification of the plan has been the discontinuance, within the last few years, of the applications of limestone, phosphate, and straw residues, after the total quantity of limestone applied had reached the average amount of 8 tons an acre and the total phosphate 4 tons an acre.

Table 8 gives a summary of the results in terms of the average annual crop yields obtained since the plots have been under complete treatment.

FIG. 12.—CLOVER ON TREATED LAND, DIXON FIELD

A cutting of red-clover hay produced under the residues, limestone, phosphate treatment. Here we have a yield of 1,319 pounds, more than two and one-third times the yield on the untreated land.

In considering these results, the most striking feature to be observed is the outstanding effect of farm manure. The average annual increase due to the use of manure alone has amounted to nearly 21 bushels of corn an acre, more than 13 bushels of oats, over 6 bushels of wheat, ¾ of a ton of clover, and ¼ of a ton of soybean hay.

Organic manure in the form of crop residues has also produced increases in yields altho not to the extent of those produced by animal manure.

Limestone in addition to organic manures has, with a single exception, effected more or less improvement. On the whole it has become increasingly profitable so that in the last rotation period it has returned a net profit per ton applied of $5.50 in the manure system and $7.00 in the residues system.

Rock phosphate, as usual, shows up to best advantage when used with residues on the wheat crop. The effect on other crops, however, has been such that the increases in yield are not sufficient to cover the cost of the application under existing market conditions.

Altho potassium has produced an average increase of 3.6 bushels an acre in corn, the effects on other crops are such as to render its use unprofitable in growing these common field crops.

THE KEWANEE FIELD

The Kewanee experiment field, located in Henry county, represents the soil type Brown Silt Loam, by far the most extensive type in Macon county. The matter of applying the results from this field to the Macon county areas is discussed on page 23.

This field has been in operation since 1915. It includes 20 acres of the dark-colored loessial soil characteristic of the region. Altho the main soil type represented is Brown Silt Loam, a detailed examination reveals the presence of a second type, Black Clay Loam On Drab Clay, occupying the basin of the draw which traverses the field in a winding direction. In topography the land is rather rolling and has a tendency to wash at certain spots. The field is laid out in two systems of plots designated as the major and the minor series. The major system is devoted to the regular series of tests and the minor to a special phosphate study.

The Major Series

A rotation system of wheat, corn, oats, and clover has been practiced on the major series, the crops being managed mainly as described on pages 48 and 49. Since 1921 the clover on the residues plots has been harvested for hay instead of seed and the oat straw has not been returned to the land. Since 1922 the periodic application of limestone has been suspended after the different series had received an average total of 6¾ tons to the acre, and no more is to be applied until it shall be needed again. The practice of returning the wheat straw has been discontinued since 1922, and since 1925 only one crop of clover hay on the residues plots has been removed, the second crop being plowed down as green manure. The phosphate applications were suspended in 1927 after evening up all phosphate plots to a total of 4 tons per acre.

TABLE 9.—KEWANEE FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1917-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *10 crops*	Corn *12 crops*	Oats *12 crops*	Clover[1] *11 crops*
1	0	29.0	54.6	59.0	(1.64)
2	M	32.4	66.0	71.0	(2.23)
3	ML	35.2	70.6	73.2	(2.30)
4	MLP	40.0	72.1	72.4	(2.48)
5	0	30.3	56.1	60.6	(1.56)
6	R	31.6	58.2	59.6	(1.46)
7	RL	34.2	66.5	63.3	(1.71)
8	RLP	39.8	70.9	69.0	(1.89)
9	RLPK	40.6	74.4	70.6	(1.97)
10	0	28.1	50.3	56.4	(1.29)
	Crop Increases				
	M over 0	3.4	11.4	12.0	(.59)
	R over 0	1.3	2.1	− 1.0	−(.10)
	ML over M	2.8	4.6	2.2	(.07)
	RL over R	2.6	8.3	3.7	(.25)
	MLP over ML	4.8	1.5	− .8	(.18)
	RLP over RL	5.6	4.4	5.7	(.18)
	RLPK over RLP	.8	3.5	1.6	(.08)

[1]Including some seed evaluated as hay.

Table 9 gives a summary of the results showing the average annual yields for the different kinds of crops, including the years since the complete soil treatments have been in effect.

In looking over these results one may observe first the effect of animal manure, which has given profitable increases in all the crops. Residues alone show no significant effect.

Limestone in addition to manure has resulted in a small improvement, probably sufficient to cover the cost. It has been somewhat more effective in the grain system than in the livestock system.

Phosphorus, as usual, shows up in these averages to best advantage on the wheat crop in the residues system. Where used with manure and limestone, little effect was produced except on the wheat; but where used with residues and limestone, fair increases were produced in all crops, sufficient to return a financial profit under present market conditions. A study of the detailed data reveals a fact of interest in this connection which these averages do not bring out, and that is that the phosphate exerted very little influence during the earlier years of the experiments. Within the past seven or eight years, however, the phosphorus treatment has come suddenly into evidence and the trend of its effectiveness seems at present to be on the upgrade.

No significant response appears as the result of potassium fertilization, thus indicating the futility of purchasing potassium fertilizer for use in this kind of a cropping system on this kind of soil.

Comparative Phosphate Experiments

Four short series having only 4 plots each constitute the so-called minor system on the Kewanee field. These plots are now given over to a comparison of the effectiveness of rock phosphate and superphosphate.

Alfalfa was grown on these plots until 1922. In the beginning, limestone was applied to Plots 3 and 4 at the rate of 4 tons an acre. This application was repeated in 1919. In 1922 the present experiments with phosphates were begun and the same rotation practiced on the larger series described above was established on these series. In this comparison rock phosphate is used on Plots 1 and 3 at the annual rate of 400 pounds an acre, applied once in the rotation ahead of the wheat, but since 1927 rock phosphate has been applied at the same time as the superphosphate. Superphosphate is used on Plots 2 and 4 at the annual rate of 200 pounds an acre. It is applied twice in the rotation, one-half for wheat and one-half for oats. A summary of the annual crop yields and corresponding money values is given in Table 10.

TABLE 10.—KEWANEE FIELD: PHOSPHATE EXPERIMENT

Average Annual Crop Yields and Corresponding Money Values 1922-1928
Bushels or (tons) per acre

Soil treatment applied	Wheat *7 crops*	Corn *7 crops*	Oats *7 crops*	Legume hay *7 crops*	Value per acre
Residues, rock phosphate	43.3	74.1	76.5	(3.09)	$43.89
Residues, superphosphate	45.1	73.0	78.2	(3.02)	44.17
Residues, limestone, rock phosphate	38.8	73.0	73.5	(3.09)	42.05
Residues, limestone, superphosphate	46.6	75.1	77.0	(3.01)	44.83

In comparing these two forms of phosphate the following set of prices are assumed as representing the average market conditions for the past seven years (December 1 quotations): wheat, $1.21 a bushel; corn, 68 cents; oats, 39 cents; and hay, $13.90 a ton. For the cost of the phosphorus carriers, an estimate of $12 a ton for rock phosphate and $24 a ton for superphosphate may be taken, thus making the expense for the two kinds of phosphate equal.

With these prices applied to the yields given in Table 10, it is found that without limestone there is very little difference in value of crops produced under the two forms of phosphate. The 28 cents in favor of the superphosphate is scarcely significant in view of the experimental errors involved in this sort of test. In the presence of limestone the difference in crop values is $2.78 per acre per year in favor of superphosphate. Wheat has been the crop most affected by the form of phosphate applied.

It is to be borne in mind that the order of values can easily be shifted by a change in the relative yields of the respective crops or by a change in commodity prices. Furthermore no consideration has been given here to any possible difference in the residual effects of the two forms of phosphate which might appear upon discontinuing the treatments.

THE BLOOMINGTON FIELD

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat; and, since 1905, they have been grown in the sequence named.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. For 20 years all of the phosphorus on this field was applied in the form of steamed bone meal at the rate of 200 pounds an acre a year.

Table 11 presents a summary of the work to 1923 by average annual yields. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they were applied.

The value of limestone on this field is difficult to assess on account of the erratic results found upon comparing Plots 1 and 2. Here both corn and wheat

TABLE 11.—BLOOMINGTON FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1902-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*	Clover[1] *3 crops*
1	0	44.6	40.6	26.5	(.74)
2	L	41.5	44.7	24.1	(.80)
3	LR	47.5	46.2	27.9	(.88)
4	LbP	55.8	54.3	45.7	(2.54)
5	LK	46.2	43.5	25.5	(.90)
6	LRbP	60.6	66.0	49.7	(1.19)
7	LRK	48.6	46.8	27.5	(.82)
8	LbPK	60.9	57.2	44.5	(2.44)
9	LRbPK	64.2	63.1	50.4	(.81)
10	RbPK	58.8	52.8	49.3	(.83)
	Crop Increases				
For limestone					
L	over 0	− 3.5	4.1	− 2.4	(.06)
LRbPK	over RbPK	5.4	10.3	1.1	−(.02)
For residues					
LR	over L	6.0	1.5	3.8	(.08)
LRbP	over LbP	4.8	11.7	4.0	−(1.35)
LRK	over LK	2.4	3.3	2.0	−(.08)
LRbPK	over LbPK	3.3	5.9	5.9	−(1.63)
For phosphorus					
LbP	over L	14.3	9.6	21.6	(1.74)
LRbP	over LR	13.1	19.8	21.8	(.31)
LbPK	over LK	14.7	13.7	19.0	(1.54)
LRbPK	over LRK	15.6	16.3	22.9	−(.01)
For potassium					
LK	over L	4.7	− 1.2	1.4	(.10)
LRK	over LR	1.1	.6	− .4	−(.06)
LbPK	over LbP	5.1	2.9	− 1.2	−(.10)
LRbPK	over LRbP	3.6	− 2.9	.7	−(.38)

[1]Two crops of seed on Plots 3, 6, 7, and 9 evaluated as hay.

appear to have suffered from the application of limestone, but the difficulty may well be attributable to soil variability. Comparing Plots 9 and 10, it would appear that in combination with residues, phosphorus, and potassium, the limestone on the whole was beneficial.

The residues treatment, supplying organic matter and nitrogen, shows a beneficial effect on the grain crops, but not on the clover.

The prominent feature of the results on the Bloomington field is the effect of phosphorus. In all of the grain crops on every plot where bone meal was applied, there was a remarkable response to the treatment, as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues, with limestone, residues, and phosphorus) we find that the phosphorus treatment produced an average annual increase in the yield of corn of about 13 bushels an acre, while the yield of oats was increased by about 20 bushels, and that of wheat by about 22 bushels. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8, where potassium instead of residues was present.

Quite different are the results from the use of potassium on this field. The potassium was applied mainly in the form of potassium sulfate, but in 1917 when this material became unavailable thru war conditions, potassium carbonate was substituted. There was a moderate increase in the corn yield where potassium was used and particularly where residues were absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is the outstanding limiting factor in production and the application of this element in the form of steamed bone meal is attended by a high financial profit.

New Phosphate Experiments

In view of this remarkable response to bone meal on the Bloomington field, it was of interest to know how other carriers of phosphorus would behave, and accordingly some experiments were planned to investigate this question. For this purpose, the plots were divided in 1924 and certain new treatments were applied in order to compare the effects of rock phosphate and of superphosphate with bone meal, and at the same time to determine the residual effect of the accumulated phosphorus resulting from the continuous application of the bone meal in presumably somewhat excessive amounts.

The following modifications of the original plots were introduced:

An extra plot, No. 11, was added to the series and all plots were divided into north and south halves. Residues, including cornstalks, the second crop of red clover, and other leguminous green manure crops are plowed down on all plots except Plot 1-S. Different phosphorus carriers are applied at the following acre-rates per rotation: bone meal, 1000 pounds, to Plots 2-N, 4-N, 6-N, 8-N, 9-N, and 10-N; rock phosphate, 2500 pounds, to Plots 3-N, 5-N, 7-N, and 11-N; superphosphate, 1000 pounds, to Plots 3-S, 5-S, 7-S, and 11-S. Two-fifths of the rota-

tion application of these phosphates is made preceding the oats crop, two-fifths ahead of the wheat crop, and one-fifth in preparation for the corn crop.

Table 12 indicates the arrangement of these modified plots and also gives the results of the five years in which these later experiments have been in progress.

In arriving at the financial results presented in the table, the values of the crops are based upon December 1 farm price quotations for the years in which the respective crops were produced. In deducting the annual cost for the different treatments, the total amounts of materials applied during the entire period of operation on the field were prorated. The expense for limestone is reckoned here at $3 a ton, rock phosphate at $14, superphosphate at $28, bone meal at $48, and residues at 75 cents an acre.

It should be mentioned in considering the results that the soil of these plots is rather variable, with little provision for duplication; and also that some of the treatments are not now strictly comparable with one another on account of the previous history of the plots. Nevertheless, making allowances for these facts, certain figures in the last column of the table showing the net average acre value per year indicate effects worthy of consideration.

TABLE 12.—BLOOMINGTON FIELD: NEW PHOSPHATE EXPERIMENTS
Crop Yields and Values 1924-1928—Bushels or (tons) and dollars per acre

Plot No.	Soil treatment applied		1924	1925	1926	1927	1928	Average annual acre values		
	Previous	Present	Oats	Clover	Wheat	Corn	Corn	Gross	Cost of treatment	Net
1-N	0	R	60.6	(.79)	29.3	49.8	49.0	$29.29	$ .75	$28.54
1-S	0	0	58.4	(2.54)	19.5	41.0	33.4	28.82	.....	28.82
2-N	L	RLP (bone)	72.6	(1.63)	35.0	58.6	52.2	36.18	6.55	29.63
2-S	L	RL	53.2	(.75)	18.7	46.0	35.2	23.41	1.75	21.66
3-N	RL	RLP (rock)	68.2	(2.18)	32.5	63.6	64.6	39.35	5.25	34.10
3-S	RL	RLP (super)	71.3	(1.74)	41.0	67.6	59.6	40.18	4.55	35.63
4-N	LP (bone)	RLP (bone)[1]	57.6	(1.81)	37.3	60.0	49.6	35.79	6.55	29.24
4-S	LP (bone)	RLP (bone)[2]	67.2	(1.89)	36.7	63.6	60.0	38.71	5.30	33.41
5-N	LK	RLKP (rock)	63.2	(1.66)	32.5	61.4	56.2	35.73	7.65	28.08
5-S	LK	RLKP (super)	78.4	(1.59)	40.7	69.4	55.6	39.99	6.95	33.04
6-N	RLP (bone)	RLP (bone)[1]	68.8	(2.18)	40.5	60.8	55.8	39.73	6.55	33.18
6-S	RLP (bone)	RLP (bone)[2]	71.6	(2.21)	40.0	64.2	60.4	41.09	5.30	35.79
7-N	RLK	RLKP (rock)	71.2	(2.11)	35.3	66.4	58.4	39.62	7.65	31.97
7-S	RLK	RLKP (super)	80.9	(1.66)	40.7	74.8	62.8	42.23	6.95	35.28
8-N	LKP (bone)	RLKP (bone)[1]	60.9	(1.69)	39.2	67.4	56.2	38.10	8.95	29.15
8-S	LKP (bone)	RLKP (bone)[2]	65.0	(1.59)	36.0	69.4	63.0	38.62	7.70	30.92
9-N	RLKP (bone)	RLKP (bone)[1]	60.9	(2.18)	43.8	75.8	60.4	42.56	8.95	33.61
9-S	RLKP (bone)	RLKP (bone)[2]	72.2	(1.65)	41.5	77.8	62.6	41.97	7.70	34.27
10-N	RKP (bone)	RKP (bone)[1]	48.2	(1.93)	45.7	56.6	51.2	37.02	7.95	29.07
10-S	RKP (bone)	RKP (bone)[2]	51.2	(1.53)	43.0	60.6	58.0	36.89	6.70	29.99
11-N	[3]	RP (rock)	70.4	(1.68)	45.3	61.8	47.4	38.43	4.25	34.18
11-S	[3]	RP (super)	60.0	(1.78)	44.5	63.0	57.2	39.11	3.55	35.56

[1]Bone meal applications omitted from 1917 to 1924. [2]No bone meal applied since 1917. [3]New plot added in 1924.

In answering the question as to whether other carriers of phosphorus would be as effective as the bone meal in building up this soil, attention is called to the results on Plots 2-N, 3-N, and 3-S where bone meal, rock phosphate, and superphosphate respectively have been employed in addition to limestone and residues. Unfortunately the comparison here is not altogether perfect in that the residues treatment on Plot 2-N was not introduced until 1924, whereas the other two plots had been under residues in the old system before the present experiments were begun and may, therefore, have an advantage in this respect over the bone-meal plot. However this may be, the results as they stand at present place both rock phosphate and superphosphate ahead of bone meal.

Between rock phosphate and superphosphate four direct comparisons in different combinations with other materials are afforded (Plots 3, 5, 7, and 11). In some years on some plots the results are in favor of superphosphate; in other years on the same plots the reverse is true. As the results stand at present, the majority are in favor of superphosphate but their inconsistency makes it difficult to come to any final conclusion. It may be noted that in these comparisons the two materials are not applied in amounts proportionate to equal cost as in other cases reported. Here 200 pounds per acre per year of superphosphate figured at $2.80 are applied against 500 pounds of rock phosphate valued at $3.50 per acre per year.

For light on the question of residual effect of accumulated phosphorus in the soil, attention is called to the results on Plots 4, 6, 8, 9, and 10, where the north half-plots are now regularly receiving bone meal, while the south halves have received none since 1917. Invariably the net return is higher on the south half, thus indicating that the reserve phosphate accumulated in the soil from previous applications is still exerting a beneficial effect that is more than adequate to offset the expense involved in renewed applications.

By way of a summary of the main lessons brought out at this time by the Bloomington experiments, the following statements may be made.

1. The results indicate an outstanding phosphorus hunger.
2. This phosphorus need is satisfied by the application of either bone meal, rock phosphate, or superphosphate.
3. There is a pronounced residual effect from previous excessive applications of phosphorus carried in the form of bone meal.

THE ALEDO FIELD

An experiment field representing the soil type Brown Silt Loam On Clay is located in Mercer county just west of Aledo. This field has been in operation since 1910. From its physical aspects this field should be well adapted to experimental work, the land being unusually uniform in topography and in soil profile.

There are two general systems of plots and they are designated as the major and the minor systems. The major system comprizes four series made up of 10 plots each. The plots were handled substantially as described for standard treatment until 1918, when it was planned to harvest the first crop of red clover on the residues plots for hay and to plow down the second crop if no seed were

formed. In 1921 the return of the oat straw was discontinued. In 1923 the rotation was changed to one of corn, corn, oats and wheat. In this rotation it was planned to seed hubam clover in the oats on all plots, for use as hay or for soil improvement, and common sweet clover in the wheat on the residues plots for use as a green manure. Since this change, no residues except cornstalks and the green manure have been returned to the residues plots. The limestone applications were temporarily abandoned in 1923 after the different series had received 7½ to 9 tons an acre and no more will be applied until a need for lime appears. The phosphate applications were evened up to a total of 4 tons an acre in 1924, and no more will be applied for some time at least.

A summary of the results, showing the average annual yields obtained for the period beginning when complete soil treatment came into sway is given in Table 13. Comparisons in terms of crop increases, intended to indicate the effect of the different fertilizing materials applied is shown in the lower section of the table.

In looking over these results, one may observe first the beneficial effect of animal manure on all crops but especially on corn. This suggests the advisability of carefully conserving and regularly applying all stable manure. Residues alone have been beneficial for the second year corn but have shown little effect on the other crops of the rotation.

Where limestone has been applied, there is usually some increase in average yields, sufficient, at least, to cover the cost of the limestone.

TABLE 13.—ALEDO FIELD: SUMMARY OF CROP YIELDS
Average Annual Crop Yields 1912-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Corn	Oats	Clover	Soybeans[1]	Stubble clover	
							Sweet clover	Hubam[2]
		14 crops	*23 crops*	*16 crops*	*6 crops*	*3 crops*	*2 crops*	*2 crops*
1	0	29.9	56.0	58.6	(2.21)	(1.60)	.....	.....
2	M	35.1	69.9	65.7	(2.74)	(1.63)	.....	.....
3	ML	35.5	73.5	68.5	(3.12)	(1.60)	.....	(1.12)
4	MLP	37.2	74.7	69.5	(3.05)	(1.61)	.....	(1.20)
5	0	31.0	58.0	60.0	(2.00)	(1.61)	.....	.....
6	R	31.8	64.5	61.5	(1.91)	(1.65)	.....	.....
7	RL	34.2	71.7	66.8	(1.79)	(1.88)	(1.57)	(.52)
8	RLP	37.9	74.1	68.3	(2.08)	(2.03)	(1.66)	(.80)
9	RLPK	37.8	75.4	70.7	(1.73)	(2.09)	(1.99)	(.57)
10	0	30.2	56.3	58.8	(2.38)	(1.62)	.....	.....
	Crop Increases							
	M over 0	5.2	13.9	7.1	(.53)	(.03)	.....	.....
	R over 0	.8	6.5	1.5	−(.09)	(.04)	.....	.....
	ML over M	.4	3.6	2.8	(.38)	−(.03)	.....	(1.12)
	RL over R	2.4	7.2	5.3	−(.12)	(.23)	(1.57)	(.52)
	MLP over ML	1.7	1.2	1.0	−(.07)	(.01)	.....	(.08)
	RLP over RL	3.7	2.4	1.5	(.29)	(.15)	(.09)	(.28)
	RLPK over RLP	− .1	1.3	2.4	−(.35)	(.06)	(.33)	−(.23)

[1]Soybeans all evaluated as hay, altho some plots were harvested as seed.
[2]Two crops hubam on Plots 3 and 4 but only 1 crop on 7, 8, and 9.

The addition of rock phosphate to the treatment has had very little effect in the manure system. Somewhat more favorable are the results in the residues system, but under present market conditions, the cost of rock phosphate applied in the manner of these experiments exceeds the value of the crop increase. However, the economic story has not all been told, for the application of lime and phosphate has been discontinued in order to observe the residual effects. The results of the next few years, therefore, will be awaited with great interest.

For the effect of potassium treatment Plots 8 and 9 should be compared. No significant response appears from this treatment so far as these common field crops show.

Special Phosphate Experiments

The so-called minor system of plots on the Aledo field is given over to a comparison of the effectiveness of different carriers of phosphorus.

In this experiment each series contains four plots. Plot 1 receives residues treatment only; Plot 2 receives residues and phosphorus in one of the forms under test; Plot 3 receives residues, limestone, and phosphorus; and Plot 4 is similar to Plot 3 with phosphorus omitted. On one series steamed bone meal is used as the carrier of phosphorus and is applied at the rate of 200 pounds per acre per year. On another series superphosphate is applied at the yearly rate of 333⅓ pounds per acre. On a third series rock phosphate serves as the source of phosphorus and is applied at the rate of 666⅔ pounds per acre per year. On the last series basic slag phosphate is applied at the rate of 250 pounds per acre per year.

The yields for all crops harvested on these plots are recorded in Table 14. Table 15, which is derived from Table 14, shows the value of the increase in crop yield presumed to have resulted from applying the various forms of phosphatic

TABLE 14.—ALEDO FIELD: PHOSPHATE EXPERIMENT
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1916[1] Corn	1917[1] Oats	1918[1] Soy-beans	1919 Wheat	1920 Corn	1921 Oats	1922 Clover hay	1923 Corn	1924 Corn	1925 Oats	1926 Wheat	1927 Corn	1928 Corn
501	R.....	53.4	85.5	18.9	32.4	72.8	48.9	(2.88)	83.5	58.2	63.9	44.0	33.9	69.8
502	RbP.....	61.7	91.7	19.0	34.7	86.4	61.9	(3.25)	82.7	66.0	75.0	59.2	63.2	71.7
503	RLbP.....	61.5	90.6	23.2	35.6	87.3	53.3	(3.48)	82.5	66.8	73.4	62.0	71.3	78.3
504	RL.....	55.1	80.5	22.6	32.9	77.7	47.7	(2.61)	88.2	60.3	64.5	44.6	58.5	72.0
601	R.....	55.2	84.7	19.5	33.0	71.2	53.6	(3.17)	84.7	57.3	64.4	43.3	37.2	71.3
602	RsP.....	57.8	87.7	18.7	38.3	87.1	60.9	(3.23)	82.5	65.9	76.1	60.6	54.8	73.2
603	RLsP.....	64.7	83.4	23.1	38.2	88.1	52.3	(3.53)	77.6	64.7	78.1	64.4	67.0	74.9
604	RL.....	51.9	81.7	24.6	32.8	84.9	50.2	(3.06)	84.1	51.9	64.1	47.3	60.8	74.4
701	R.....	54.3	83.1	20.8	34.2	75.6	52.8	(3.41)	82.8	61.2	66.6	44.8	39.9	72.3
702	RrP.....	58.8	83.3	23.3	36.7	80.4	63.0	(3.60)	87.8	69.3	70.3	59.2	61.8	74.3
703	RLrP.....	57.2	81.2	28.1	36.7	80.2	53.3	(3.82)	86.6	70.8	67.8	57.5	67.8	76.5
704	RL.....	52.1	81.7	26.9	34.1	82.0	48.9	(3.15)	84.6	62.5	66.3	48.8	63.0	74.6
801	R.....	57.6	73.8	18.0	33.7	68.1	54.8	(2.62)	74.3	58.8	45.0	45.8	42.2	70.4
802	RslP.....	56.4	87.8	20.6	38.1	81.0	66.2	(3.66)	80.0	69.1	66.3	60.2	60.7	69.3
803	RLslP.....	53.3	78.9	23.7	38.4	83.6	57.0	(3.63)	82.0	70.2	66.7	66.0	73.1	71.0
804	RL.....	51.8	77.5	21.8	33.3	70.4	59.8	(2.99)	82.6	59.9	53.9	48.2	60.4	75.1

[1]No residues.

fertilizers for the 13 crops harvested since the beginning of the applications up to 1928. In computing these comparisons, each phosphate plot is compared with its neighboring non-phosphate plot. Aside from the soybeans, the figures show without exception more or less crop increase on the phosphorus plots, no matter what the form of carrier employed.

The difficulty in arriving at a general conclusion regarding the comparative economy in the use of these different phosphorus materials is obvious, for all depends upon their relative cost, which fluctuates from time to time Furthermore, the prices received from farm produce likewise fluctuate; and to complicate matters still further, these fluctuations do not necessarily run parallel with those of the fertilizer cost. However, one may compute for himself the relative economy of producing these crop increases by applying any set of prices for crops and fertilizers which appear to be most applicable according to prevailing market conditions. For the purpose of furnishing an illustration of such a computation, the December 1 market quotations for the years in which the respective crops were actually produced have been applied to the results of these Aledo plots. The value of soybeans is arbitrarily set at $1.50 a bushel. For the cost of fertilizer materials the prices of phosphates are estimated as follows: bone meal, $40 a ton; superphosphate, $24; rock phosphate, $12; and slag phosphate, $20 a ton.

Reckoned on the basis of the above prices, it appears from the last column of Table 15 that slag phosphate has produced the most profitable returns of the four phosphorus carriers in the test, bringing an average profit of $4.89 an acre yearly where applied without limestone and $3.57 where applied with limestone.

TABLE 15.—ALEDO FIELD: PHOSPHATE EXPERIMENTS
Value of Crop Increases Produced by the Various Forms of Phosphate, Computed From Yields in Table 14

Comparison of treatments	Wheat *2 crops*	Corn *6 crops*	Oats *3 crops*	Clover *1 crop*	Soybeans *1 crop*	Total increase *13 crops*	Cost of phosphate *13 crops*	Profit from *13 crops*	Profit per acre per year
Bone meal, residues, *over* residues	$23.35	$44.04	$11.67	$ 4.63	$ .15	$83.83	$52.00	$31.83	$ 2.45
Bone meal, residues, lime, *over* residues, lime	26.90	27.01	11.31	10.88	.90	77.00	52.00	25.00	1.92
Superphosphate, residues, *over* residues	32.23	32.12	8.15	.75	− 1.20	72.05	52.00	20.05	1.54
Superphosphate, residues, lime, *over* residues, lime	32.20	25.33	6.62	5.88	− 2.25	67.77	52.00	15.77	1.21
Rock phosphate, residues, *over* residues	22.81	34.51	4.38	2.38	3.75	67.83	52.00	15.83	1.22
Rock phosphate, residues, lime, *over* residues, lime	16.07	17.15	1.49	8.38	1.80	44.89	52.00	− 7.11	− .55
Slag phosphate, residues, *over* residues	26.80	32.46	19.86	13.00	3.90	96.02	32.50	63.52	4.89
Slag phosphate, residues, lime *over* residues, lime	32.43	24.59	11.07	8.00	2.85	78.94	32.50	46.44	3.57

Bone meal has given an average profit of $2.45 applied without limestone and $1.92 applied with limestone. Superphosphate has returned $1.54 used without limestone and $1.21 used with limestone. Rock phosphate has produced a profit of $1.22 an acre a year when applied without limestone and a loss of 55 cents when used with limestone.

In considering these results, it may be pointed out that the quantities of phosphatic materials employed in these experiments are, with the possible exception of the slag phosphate, greater than ordinarily would be used, or need to be used, in good farm practice. Moreover, no consideration is given in these comparisons to the relative phosphorus reserves which should have accumulated in the soil. Finally, it should be emphasized that the order of these values might be easily shifted by relatively small change in commodity prices.

Limestone at the rate of 4 tons an acre was applied to Plots 3 and 4 in 1912 when the land was still under alfalfa, and another dressing was added in 1917 after the present experiments were under way. The results from the limestone treatment are shown in Table 16.

At the prices for produce and limestone assumed in these computations, a profit of $1.69 an acre a year for limestone applied without phosphate of any kind is found. Where limestone was applied with bone meal, the limestone profit was 99 cents an acre a year, and with superphosphate it was likewise 99 cents an acre. Used with rock phosphate, the crop increases were so small that there was a loss of 10 cents an acre a year. Applied with slag phosphate, the returns show a profit of 94 cents an acre a year.

TABLE 16.—ALEDO FIELD: PHOSPHATE EXPERIMENTS
Value of Crop Increases Produced by Limestone, Computed From Yields in Table 14

Comparison of treatment	Wheat *2 crops*	Corn *6 crops*	Oats *3 crops*	Clover *1 crop*	Soy-beans *1 crop*	Total increase *13 crops*	Cost of lime-stone[1] *13 crops*	Profit from *13 crops*	Profit per acre per year
Limestone, residues, *over* residues	$3.25	$22.14	$−.40	$−.84	$7.01	$31.16	$9.18	$21.98	$1.69
Limestone, residues, bone meal, *over* residues, bone meal	5.31	11.35	−3.76	2.88	6.30	22.08	9.18	12.90	.99
Limestone, residues, superphosphate, *over* residues, superphosphate	4.43	11.93	−4.58	3.75	6.60	22.02	9.18	12.84	.99
Limestone, residues, rock phosphate, *over* residues, rock phosphate	−2.07	5.00	−5.04	2.75	7.20	7.84	9.18	− 1.34	− .10
Limestone, residues, slag phosphate, *over* residues, slag phosphate	7.71	11.26	−1.81	− .38	4.65	21.44	9.18	12.26	.94

[1]Owing to the fact that the first application of limestone on these plots was made for alfalfa four years before the present experiments were started, the total expense of $12 an acre for limestone is prorated, leaving a charge of $9.18 for the 13 crops involved in the present experiments.

It appears, therefore, that by distributing the cost of the limestone over the years since its first application, this material has returned a moderate profit except where used with rock phosphate.

It should be observed that the Aledo field represents one of those borderline cases, so to speak, in which the upper soil is nearly neutral or only slightly acid and the lime requirement, therefore, is not very marked. As time goes on, however, and cropping continues, a greater need for lime will probably develop. By discontinuing liming on these plots the annual cost of the limestone already applied is automatically reduced, so that net returns which hitherto have perhaps represented an actual loss may sooner or later result in a positive profit.

THE HARTSBURG FIELD

Black Clay Loam, as noted on page 24, occupies over 100 square miles in Macon county. The results of the Hartsburg field, situated in Logan county just east of the town of Hartsburg, are suggestive of the treatments that are effective on this type of soil.

The Hartsburg field was started in 1911. It is laid off in five series of 10 plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series.

The crops were handled mainly as described on pages 48 and 49 until 1918, when it was planned to remove one hay crop and one seed crop of clover from the residues plots. In 1921 it was decided to harvest all the clover as hay. At that

TABLE 17.—HARTSBURG FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1913-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Barley	Corn	Oats	Clover	Soy-beans	Alfalfa	Stubble clover	
									Hubam	Sweet clover
		13 crops	*1 crop*	*24 crops*	*17 crops*	*7 crops*	*2 crops*	*8 crops*	*1 crop*	*1 crop*
1	0	24.9	35.4	48.1	48.1	(1.84)	(1.29)	(3.47)	(.83)	.....
2	M	29.2	44.2	58.8	52.9	(2.16)	(1.64)	(3.67)	(1.15)	.....
3	ML	34.0	50.0	64.5	58.3	(2.32)	(1.82)	(3.91)	(.91)	.....
4	MLP	36.2	50.0	63.8	57.8	(2.39)	(1.92)	(4.19)	(1.17)	.....
5	0	29.7	42.7	53.3	47.0	(1.28)	25.8	(3.33)	(.71)	.....
6	R	32.7	47.5	63.7	53.3	(1.67)	26.8	(3.78)	(.75)	(.85)
7	RL	30.1	53.3	66.9	51.3	(1.64)	28.4	(3.45)	(.68)	(.75)
8	RLP	34.3	46.9	67.3	55.4	(1.79)	26.1	(4.04)	(.72)	(.90)
9	RLPK	33.4	55.6	65.4	54.5	(1.70)	26.4	(4.16)	(.80)	(1.00)
10	0	30.5	45.8	52.8	48.0	(2.02)	(1.69)	(3.20)	(.75)	.....
	Crop Increases									
	M over 0	4.3	8.8	10.7	4.8	(.32)	(.35)	(.20)	(.32)	.....
	R over 0	3.0	4.8	10.4	6.3	(.39)	1.0	(.45)	(.04)	(.85)
	ML over M	4.8	5.8	5.7	5.4	(.16)	(.18)	(.24)	−(.24)	.....
	RL over R	− 2.6	5.8	3.2	− 2.0	−(.03)	1.6	−(.33)	−(.07)	−(.10)
	MLP over ML	2.2	0.0	− .7	− .5	(.07)	(.10)	(.28)	(.26)	.....
	RLP over RL	4.2	− 6.4	.4	4.1	(.15)	− 2.3	(.59)	−(.04)	(.15)
	RLPK over RLP	− .9	8.7	− 1.9	− .9	−(.09)	.3	(.12)	(.08)	(.10)

time the return of the oat straw to the land was discontinued. In 1922 the return of the wheat straw was likewise discontinued. The application of limestone was discontinued in 1922 after amounts ranging from 7½ to 10 tons an acre on the different series had been applied, and no more will be added until further need for it becomes apparent. In 1923 the phosphate applications were evened up to a total of 4 tons an acre on all phosphate plots, and no more will be applied for an indefinite period. At that time the rotation on the first four series was changed to corn, corn, oats, and wheat with a seeding of hubam clover in the oats on all plots, and a seeding of biennial sweet clover in the wheat on the residues plots. The rotation was changed also on the fifth series to corn, oats, wheat, and a mixture of alfalfa with red clover. The soil treatments are as indicated in Table 17, which summarizes by crops the yields for the period during which the plots have been under full treatment.

The outstanding feature of the results on the Hartsburg field is the large increases produced by organic manure whether in the form of crop residues or stable manure. The behavior of limestone is rather peculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure it shows some increase in practically all crops, while with residues its effect on several of the crops appears negative.

Altho rock phosphate has given some increases in wheat yield in both the manure and the residues systems, the results with other crops have been such as to render the use of this material unprofitable on this field. The addition of potassium appears to have produced no significant effect except on the one barley crop.

THE VIENNA FIELD

Macon county, as indicated in the descriptions of certain of its soil types, includes considerable land that is subject to destruction thru erosion or washing. Yellow Silt Loam, which occupies about 20 square miles in the county, is particularly susceptible to this kind of damage. Operators of land in Macon county will therefore be interested in experiments conducted on the Vienna field, in Johnson county, to test out different methods of reclaiming badly gullied land and preventing further erosion.

The Vienna field is representative of the sloping, erodible land so common in the extreme southern part of the state. When the experiments were started the whole field, with the exception of about three acres, had been abandoned because so much of the surface soil had washed away, and there were so many gullies that further cultivation was unprofitable. For the purpose of the experiments the field was divided into different sections (see Table 18). These were not entirely uniform; some parts were much more washed than others, and portions of the lower-lying land had been affected by soil material washed down from above. The higher land had a very low producing capacity; on many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except the one designated as D, which included but three plots.

FIG. 13.—PROPER SOIL AND CROPPING METHODS WOULD HAVE PREVENTED THIS CONDITION
This abandoned hillside is just over the fence from the field shown in Fig. 14. Yellow Silt Loam is particularly susceptible to this kind of damage.

Careful records were kept for nine years. The results, summarized in Table 18 indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels on the check series (D). Wheat yielded 11.1 bushels on the protected series, in comparison with 4.6 bushels on the check, and clover yielded ⅘ of a ton on the protected series and but ⅕ of a ton on the check.

TABLE 18.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields, 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

Section A included the steepest part of the field and contained many gullies. The land was built up into terraces at vertical intervals of 5 feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

Section B was used to test the so-called embankment method. Ridges were plowed up which were sufficiently high so that when there were heavy falls of rain the water would break over and run in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about 8 loads of manure an acre were turned under each year for the corn crop.

Section D was washed to about the same extent as Section C. It was farmed in the most convenient way, without any special effort to prevent washing.

FIG. 14.—CORN GROWING ON AN IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD
This land had formerly been badly eroded. It was reclaimed by proper soil treatment and cropping. Compare with Fig. 13.

Figs. 13 and 14 serve further to indicate what may be done with this type of soil even after it has become badly washed and gullied.

Altho these results show in principle the possibility of improving this land, it cannot be said that the experiments as conducted represent directly the most economical system of farming. However, it appears possible that by modifying the cropping plan in some manner, as for example, substituting sweet clover for cowpeas and giving large place in the farming system to hay and pasture crops, production might be substantially increased and thus a system of farming instituted that would represent a profitable enterprise.

Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
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41 Henry, 1928
42 Morgan, 1928
43 Douglas, 1929
44 Coles, 1929
45 Macon, 1929

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 46

EDWARDS COUNTY SOILS

By E. A. NORTON, R. S. SMITH, E. E. DeTURK, F. C. BAUER and L. H. SMITH

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URBANA, ILLINOIS, JULY, 1930

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

IT IS A MATTER of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in the form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Edwards county was conducted, and Mr. H. C. Wheeler, who, as leader of the field party, was in direct charge of the mapping.

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EDWARDS COUNTY SOILS

By E. A. NORTON, R. S. SMITH, E. E. DeTURK, F. C. BAUER and L. H. SMITH[1]

LOCATION AND SETTLEMENT OF EDWARDS COUNTY

EDWARDS COUNTY is located near the Wabash river in southeastern Illinois. It is nearly rectangular in shape, measuring 22 miles north and south by about 11 miles east and west. It is one of the smallest counties in the state, comprizing only 218.41 square miles. The population in 1920 was 9,431, more than half of which was rural; there were only four towns with more than 500 and none with over 2,000 inhabitants. Albion is the county seat.

In the section of the state where Edwards county is located no one special type of farming greatly predominates, tho grain farming is probably the most important. The soils of the county are generally light colored and vary from poor and marginal to rich and highly productive. The rainfall, temperature, and growing season are favorable for a wide variety of crops. Markets are readily accessible. Both truck and railroad transportation are well developed. Recently built paved roads, together with secondary gravelled roads, make it possible for every farmer to be within a mile or two of an all-weather road. Educational facilities and social life are considerably above the average of rural development. Farm buildings and equipment indicate moderate prosperity in all but a few communities in the county.

HISTORY OF AGRICULTURAL PRODUCTION

The first settlement in Edwards county was established at Albion in 1818. Some of the early settlers having emigrated from England, it was natural that the early agriculture was patterned after that practiced in England during the forepart of the nineteenth century. The raising and marketing of livestock were the chief agricultural enterprises. Livestock was placed on flatboats which were drifted down Bon Pas creek and Little Wabash river to Wabash river, and thence down to Shawneetown, Paducah, and other marketing points. It is reported that corn sold for 10 cents a bushel and hogs for $1.25 a hundred at Albion in 1820. The early settlers soon realized that the prairie land was better adapted to the growing of small grain and hay than to corn because the weather frequently remained cold and wet into late spring. Wheat soon became an important crop and was the first grain to be shipped from the county.

The amount of land in farms increased gradually from 1818 until 1850, at which time 57,000 acres were utilized for farming. The increase following 1850 was rapid, and by 1880 almost 90 percent of the total area of the county was turned to farm use. The number of farms increased in correspondence with the increase in total acreage utilized, reaching a peak of about 1,300 near the year 1910. There has been some decline since then, only 1,137 farms being reported in 1925. The size of the farms has remained almost stationary, averaging 101 acres in 1910 and 105 acres in 1925.

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The percentage of tenantry has never been great in this territory; it has hovered around 20 percent for the past forty years.

The principal crops grown in Edwards county are those common in north-central United States. The following data, taken from the United States Census of Agriculture in 1925, gives the acreage, production, and yield per acre of the more important crops:

Crops	*Acreage*	*Production*	*Yield per acre*
Corn (total acreage)	30,366	.....	.....
Corn harvested for grain	28,702	852,678 bu.	29.7 bu.
Corn cut for silage	668	4,517 tons	6.7 tons
Corn cut for fodder	619	.....	.....
Corn hogged off	377	.....	.....
Wheat, winter	11,694	109,955 bu.	9.4 bu.
Oats, threshed	6,760	188,021 bu.	27.8 bu.
Hay (total acreage)	21,082	20,131 tons	.9 ton
Hay, timothy alone	3,073	.....	.....
Hay, timothy and clover	1,262	.....	.....
Hay, clover (red, alsike, and mammoth)	2,340	.....	.....
Hay, alfalfa	34	.....	.....
Hay, tame grasses	11,339	.....	.....
Hay, annual legumes	2,522	.....	.....

The above Census figures are for but a single year, that of 1924. For the past ten-year period, 1919 to 1928, the U. S. Department of Agriculture and the Illinois Department of Agriculture give the average yields of the four most important crops in Edwards county as: corn, 26.6 bushels an acre; wheat, 12.2 bushels; oats, 20.5 bushels; hay, 1.1 tons. These average yields are somewhat higher than the averages for the surrounding counties but are considerably below the all-state averages. The predominance of the acreage given over to

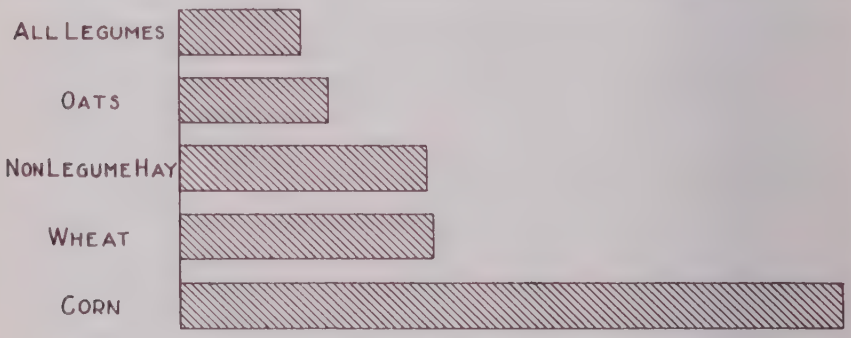


FIG. 1.—RELATIVE ACREAGE OF FIELD CROPS IN EDWARDS COUNTY, 1924

The diagram brings out the small proportion of land devoted to legumes. A well-balanced system for soil improvement demands a much larger acreage of legume crops. (Data from the 1925 Census)

corn, oats, wheat, and tame hay (Fig. 1) indicates that more diversification might well be practiced if production is to keep pace with waning fertility. The legume acreage, according to the Census figures, was less than one-tenth of the total acreage. At least one-fourth of the cropped area should be in legumes every year.

Fruit and vegetable crops are not commercially important in Edwards county. A few orchards have been developed profitably, but practically all

the fruit and vegetables raised are consumed locally. A few peaches and apples are trucked out of the county in years of local crop abundance. Good markets are readily accessible both by truck and railroad and undoubtedly special vegetable crops could be grown profitably if produced on a commercial basis.

The character of the livestock interests in the county in 1925 is shown by the following data taken from the Census:

Animals and Animal Products	*Number*	*Value*
Horses	3,993	$213,589
Mules	1,181	81,730
Cattle (total)	7,649	265,595
Dairy cows	2,280	.....
Dairy products	.....	109,126
Sheep	3,120	30,892
Hogs	14,517	152,793
Chickens and eggs sold	.....	446,737
Wool	.....	7,103

The total value of the livestock in Edwards county in 1925 was $926,494. No one particular class stands out as most important, and this bears out the statement that farming in the county is not specialized. Fig. 2 shows diagrammatically the relative value of different classes of livestock. In accord-

FIG. 2.—RELATIVE VALUE OF DIFFERENT CLASSES OF LIVESTOCK IN EDWARDS COUNTY
(Data from the 1925 Census)

ance with estimates made by the U. S. Department of Agriculture and the Illinois Department of Agriculture, little change has taken place in the number of livestock in Edwards county since 1925. The number of horses and cattle has decreased slightly; the number of sheep and hogs has increased.

CLIMATE

The climate of Edwards county is typical of that prevailing in this part of the Mississippi valley. It is characterized by a wide range between the extremes of winter and summer and by an abundant rainfall. The greatest range in temperature for any one year of a thirty-two-year period, as recorded at

the weather station located in Albion from 1897 to 1918 and in Fairfield from 1918 to 1929, was 123 degrees in 1899. The highest temperature was 108° in 1914; the lowest, 21° below zero in 1899. The average date of the last killing frost in the spring is April 15; the earliest in autumn is October 22. The average length of growing season is 190 days, which is ample time to mature all the common crops grown in the region. Occasionally early frosts produce soft corn in backward seasons or in seasons following a very wet spring. Winter wheat is often injured, particularly on flat ground, owing to a sudden drop in temperature following a rainy period in winter or early spring. Hot early summer weather often cuts the yield of spring-sown small grain. A prolonged period of hot weather, coupled with drouth, frequently reduces the yield of corn.

The prevailing wind in spring and summer blows from the south; in winter it comes from the northwest. Spring winds are usually brisk and summer winds mild except before thunder showers. A series of strong northwesterly gales bringing cold waves, which are followed by periods of relative calm, characterize the winter winds. Edwards county lies within the region subject to tornadoes but none resulting in serious destruction are known to have visited the area.

The average annual rainfall, as recorded at Albion and Fairfield for the last thirty-two years, is 41.53 inches. The rainfall during the growing season thru this period averaged 22.72 inches. The wettest year on record, 1898, had a total rainfall of 55.09 inches; the driest year, 1924, had 31.43 inches. For the wettest and driest months respectively, the records show that March, 1898, had a total rainfall of 12.39 inches, while October, 1908, had only a trace. Some of the yearly precipitation falls as snow in the winter months. The records show a yearly average of 16 inches of snow. Sleet storms are not uncommon. Occasionally hail storms occur in late spring and summer, but damage as a result of them is usually local.

The data in Fig. 3 taken by themselves would indicate that the rainfall in Edwards county is well distributed and that serious drouths were not to be expected. Average monthly precipitation, however, is not the sole index to moisture conditions; at least six other factors are important. These are: type of soil, rate at which rain falls, lapse of time in days between precipitation periods, temperature, wind, and kind of crops grown. The upland soils in Edwards county are of such nature that water moves thru them either freely or else very slowly, and a period of about twenty days without precipitation during the hot summer months reduces the moisture in the soil to a minimum for plant growth. Records show that every few years periods of twenty days or more elapse without enough rainfall for crop needs. A few serious drouths have been experienced. Crops such as corn, meadows, and pastures, which have a heavy moisture demand in July and August, are most seriously affected.

The rate at which rain falls has an important bearing not only on the amount of moisture that becomes available to plants but also on soil erosion. No records on the rate of rainfall are available, but much of the water which

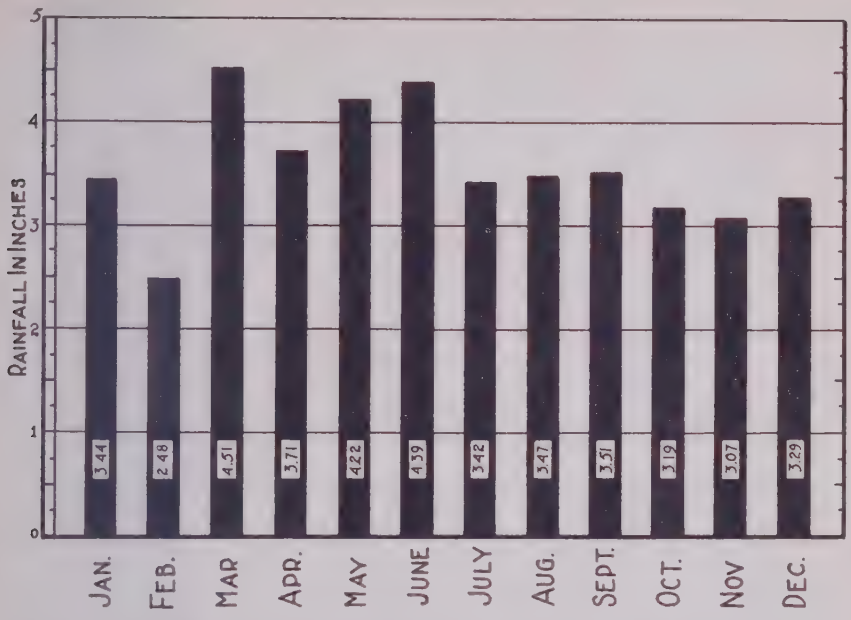


FIG. 3.—AVERAGE MONTHLY DISTRIBUTION OF RAINFALL IN EDWARDS COUNTY

falls, both from prolonged spring rains and from hard, dashing thunder showers in summer, is more destructive than beneficial. Several such rains occur in the county nearly every year. They make the control of erosion on cultivated areas, particularly on rolling land, a serious problem. Equally as important as the loss from erosion is the loss from overflow on the flat bottom lands. Losses from these two agents of destruction were particularly noticeable during the wet years of 1927 and 1928.

PHYSIOGRAPHY AND DRAINAGE

The general elevation of Edwards county is between 400 and 540 feet above sea level. The remnants of the former flat plain in the northern part of the county stand at an elevation of slightly over 500 feet. Most of the bottom land lies at an elevation slightly below 400 feet, giving a general relief of somewhat more than 100 feet. The north half of the county is badly cut up by numerous steep gullies which have forced their way back into the once flat upland. All that remain of this original plain are a few disconnected level tracts, most of which are included in an area that appears as a ridge one to two miles wide running in a northeast-southwest direction thru the northern part of the county. The central and southern parts of the county are made up of a series of ridges and irregular upland areas separated by broad, flat bottom lands. The slopes of these ridges are smoother than those of the gullied country to the north. The altitudes of a few towns in Edwards county are as follows: Albion, 531 feet above sea level; Browns, 403; Grayville, 397 (bottom land); West Salem, 508. The altitude at the point of the entrance of Bon Pas creek into Wabash river is 380 feet above sea level.

Natural drainage in Edwards county is well established. Bon Pas creek and Little Wabash river, which flow south along the eastern and western borders of the county, drain most of the area. A few sections in the southeast corner of the county drain directly into Wabash river. Fig. 4 shows the stream courses and other physiographic features of the county. All the up-

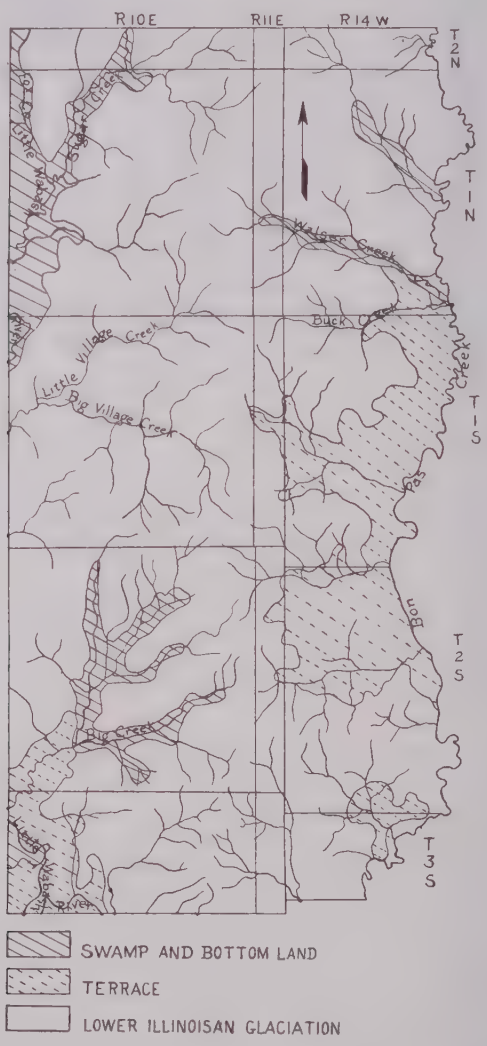


FIG. 4.—DRAINAGE MAP OF EDWARDS COUNTY SHOWING STREAM COURSES AND OTHER PHYSIOGRAPHIC FEATURES

land except a few flat areas lying on the original plain in the northern part of the county are well drained. The lowlands along Bon Pas creek drain well except in time of high water when there is no outlet to Wabash river. The lowlands along Little Wabash river remain wet late into early summer and overflow following every heavy rain.

The soils in the county as a whole are well drained, primarily because they lie on rolling surfaces. The problem on these rolling surfaces is not to provide drainage but to protect the soil from erosion. The flat upland areas have a sticky, plastic subsoil which makes underdrainage impossible. Surface-ditching must be provided in these areas. The lowland soils can be artificially drained provided an outlet can be obtained. Dredging, ditching, and tiling are the methods to employ in procuring better drainage in the bottom-land soils.

SOIL FORMATION

The few remaining nearly-level upland tracts in northern Edwards county indicate that this area was formerly a part of that unusually flat plain which stretches across central-southern Illinois. Erosion has dissected that part of the plain in Edwards county, forming numerous gullies and small bottom lands. The soils developed on these flat upland surfaces are gray in color, have compact, plastic, almost impervious subsoils, and are not highly productive. The remaining ridges and generally uneven upland terrain in the central and southern parts of the county indicate that this area was not originally flat but was rolling. The soils developed on these rolling surfaces are yellowish in color, friable, and moderately productive. Such a contrast in topography and soil development in adjacent areas can be explained only by recounting some of the events of earlier earth history.

ORIGIN OF TOPOGRAPHY AND SOIL MATERIAL

The bedrock which serves as a foundation for the loose surface mantle covering the country was formed during a remote period in geological time. The name Carboniferous is assigned to this period because its formations include many important coal-bearing strata. During Carboniferous times the land was submerged and a shallow sea extended over much of the territory now known as central United States. Existing in this sea were enormous swamps, the vegetation of which was periodically buried by an avalanche of sediment. Gravel, sand, silt, and clay were swept down into the sea during flood periods. This covering of sediment excluded air and pressed heavily on the buried vegetable material, causing the transformation of this material into coal. Altho the coal beds are of great commercial importance, their total thicknesses are insignificant in comparison with the enormous thicknesses of shale and sandstone formed from the sediments deposited during this period. Thin seams of limestone were formed locally during relatively brief intervals when the water in the sea became deeper. All these formations outcrop in Edwards county but most of the immediate bedrock surface consists of shale and sandstone.

With the general withdrawal of the sea and the emergence of the land the Carboniferous period came to a close. The elevation of the land above the sea exposed the rock surfaces to weathering and erosion. For an extended period—that is, for thousands upon thousands of years—rock destruction and removal went on ceaselessly until the country became rough and broken, cut by numerous gullies and stream valleys. The hilly land thus produced was

very different from the present land surface and entirely unsuited to farming. A change in regional climate closed this cycle of erosion and ushered in another geological period. During this period the material that later formed the mineral portion of the present soil was deposited.

The climate during this geological period, known as the Glacial epoch, was cooler than at present. Snow and ice collected in regions to the north in such amounts that the mass pushed outward from these centers of accumulation. Moving chiefly southward, these great masses of ice known as glaciers pushed across the country until they reached a place where the climate was warm enough to melt the ice as rapidly as it advanced. In this movement the ice gathered up all sorts and sizes of materials, including clay, sand, gravel, boulders, and even immense masses of rock. Some of these materials were carried hundreds of miles and rubbed against surface rocks and each other until largely ground into powder. When a glacier reached the limit of its advance the rock material carried by it accumulated along the front in a broad, undulating ridge, or moraine. With rapid melting the glacier receded and the material was deposited somewhat irregularly over the surface previously covered. Each advance and retreat leveled off ridges, hills, and high land, and filled in valleys. The mixture of materials deposited by the glacier is known as glacial drift, a term frequently referred to in describing soil types.

At least six great ice sheets moved southward, each of which covered a part of North America, altho the same parts were not covered during each advance. The movements of these individual ice sheets were separated by long periods of time during which the climate became so warm that the country was clothed with vegetation. At least one of the glaciers, known as the Illinoian, reached Edwards county. The Illinoian glaciation completely covered the county and buried or destroyed the deposits which might have been left by an earlier ice sheet. The deposits left by the Illinoian were a heterogeneous gravelly mass of drift, varying in thickness from a few feet on the old ridges to a hundred feet or more in the valleys. The northern part of Edwards county was leveled off to a flat plain, but the deposits in the central and southern parts were not thick enough to hide completely the previous topography, altho it was made much smoother than it was before glaciation.

Associated with the withdrawal of an ice sheet and the exposure of the deposited material to weathering forces was the accumulation of a silty, wind-blown material on top of the glacial drift. This wind-blown material is called loess. It was derived largely from the sediment deposited from the immense volumes of water which flowed from the melting ice sheet. This water filled the drainage channels and overflowed adjacent lowlands. Following each flood state the water would recede and the sediment deposited would dry and be picked up by the wind and redeposited on the upland as dust. Undoubtedly some fine material was also left on the surface directly by the receding glacier and more accumulated as weathering broke down the larger particles. When dry this was also blown about by the wind, collecting chiefly on the south side of ridges and other obstructions. The lack of vegetation on the land surface at this time gave the wind much more force near the earth's surface than it otherwise would have had.

Most of the loess deposited over Edwards county came from the Wabash river valley, as indicated by a thinning out of the material in all directions away from the bottom land. Local deposits, particularly along Little Wabash river, signify that the smaller stream valleys furnished some of this material. The thickness of the loess deposit over Edwards county varies from a few inches in the northern part to eight or ten feet on the bluffs along Wabash river. Altho none of the ice sheets following the Illinoian actually touched Edwards county, they furnished sediment to the Wabash river valley, which was blown over the upland as loess. Some loess accumulation took place following the Iowan glaciation but it was not widespread. The material deposited following the Wisconsin glaciation was confined to a very narrow belt along Wabash river. The difference in age of loess deposition explains in part the variation in soil productivity in Edwards county.

Erosion was continually active thruout the entire Glacial period except for the time that ice actually covered the land surface. Enough time has elapsed since the recession of the Illinoian glacier so that the region has been again reduced to a somewhat hilly topography. Only small tracts of the original surface remain. The large, flat valleys in the southern half of the county indicate that erosion has made rapid progress in tearing down the upland, while the narrow bottom lands and steep gullies in the northern part indicate a younger stage of topographic development.

SOIL DEVELOPMENT

Many processes have acted upon the original material deposited as loess or drift to work it over into the soils as we know them today. When first deposited, the general composition of any soil material, particularly loess, is rather uniform. With the passing of time, however, various physical, chemical, and biological forces form soil out of this parent material. The manner in which these forces act depends upon the environmental factors such as climate, topography, drainage, vegetation, and biological agencies. The environmental factors in addition to the parent material determine soil characteristics.

A most important process in soil development is oxidation. It occurs when the soil material is exposed to the air, and it proceeds with great rapidity when conditions are favorable. Leaching is another fairly rapid soil-forming process. Water in contact with the soil material dissolves certain substances, some of which react chemically upon one another and thru the leaching process they are translocated from one depth to another or else are washed away. Lime is one of the readily soluble compounds and its continuous loss finally causes soil acidity to develop. Finely divided particles in suspension are also carried down by the water, and under certain circumstances they accumulate in the subsoil to such an extent as to form an almost impervious stratum. Such a layer impedes moisture movement both downward and upward, and the result is a poorly drained soil in wet seasons and a drouthy soil in dry seasons.

Alternate wetting and drying, freezing and thawing, and other climatic changes also influence the development of soil. The decay of vegetable material and its incorporation into a soil produces a dark color and adds nutrient material, particularly nitrogen.

One of the most pronounced characteristics produced by weathering is the arrangement of the soil into layers, or zones. Differences in the arrangement, thickness, and characteristics of these zones constitute one of the chief characteristics for separating soils into types.

In studying soil types, as many readily observable characteristics as possible are examined. Some of these characteristics have an important bearing upon productivity; others may have no known practical relation whatsoever, but may be useful in identifying types. The size of the individual soil particles and the amount of organic matter in the soil largely determine the ease with which it may be cultivated. The character of the subsoil determines underdrainage. Young soils are usually more productive than old or mature soils because they have not been so thoroly leached of their readily available plant-food materials. The age of the soil frequently determines its reaction, whether acid, neutral, or alkaline. Soil color influences soil temperature, an important factor in the germination of seeds sown in spring.

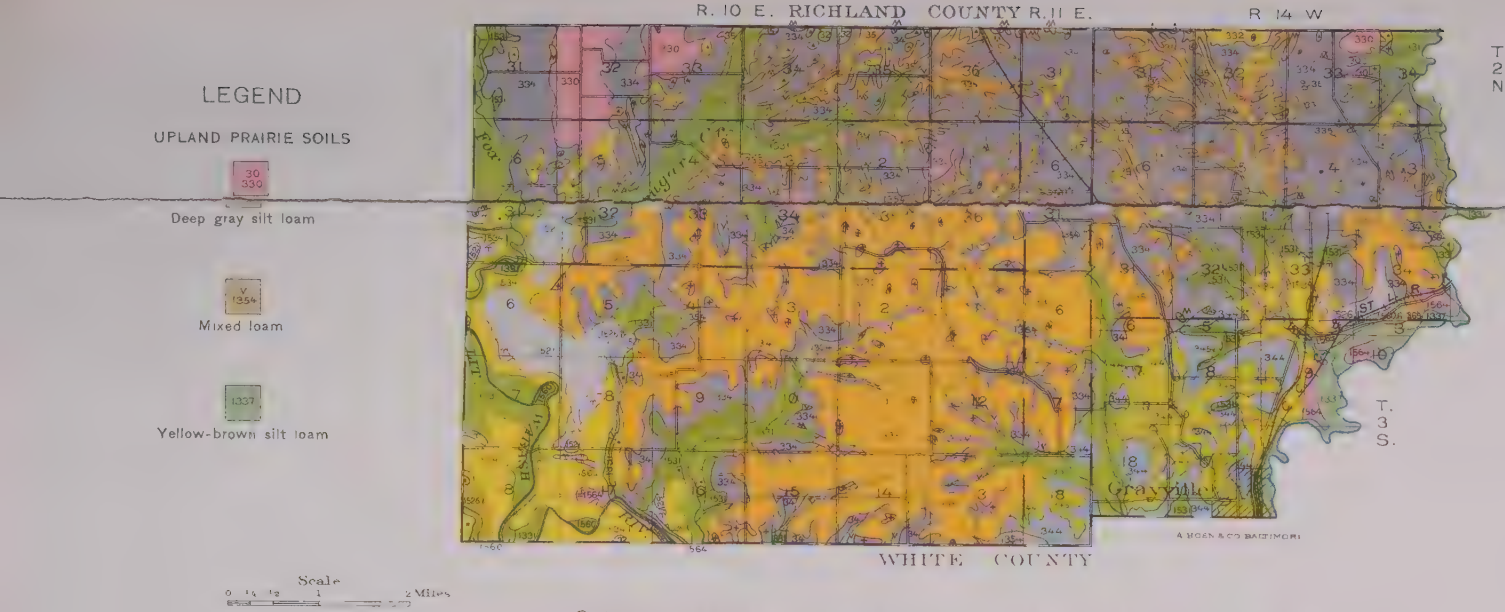
In describing a soil the characteristics of the individual strata that make up the soil profile are considered. For practical purposes these various layers, or zones, in the soil can be grouped into surface, subsurface, and subsoil. Each of these may have two or more subdivisions. The surface layer is the upper 3 to 10 inches. This is the part of the soil that is cultivated and in which most of the plant roots are found. The subsurface layer, lying immediately below the surface, is usually lighter in color. The subsoil generally begins at depths of 12 to 24 inches; it has two important divisions. The upper subsoil is more compact and plastic than any other soil layer. It varies from a slightly compact and plastic consistence in soils developed under good drainage to an extreme compactness and plasticity in soils developed under poor drainage, becoming in some soils almost impervious to water. The lower subsoil is more friable than the upper subsoil, and is usually grayish yellow in color. It begins at 25 to 60 inches.

Soils in bottom lands or in areas subject to overflow, including some of the low-lying upland, and those on steep slopes show little or no development into surface, subsurface, and subsoil. The continued deposition on overflow land and the removal of material on steep slopes proceed too rapidly to allow layers to develop. The surface layer on overflow land is often rather thick, and that on steep slopes is likely to be thin or it may be entirely absent.

SOIL GROUPS

The accompanying colored map gives the location and boundary of each soil type and indicates the position of streams, roads, railroads, and towns. The list of soil types, the area of each in square miles and in acres, and also the percentage of the total area as recorded on the map are shown in Table I. The soil types are arranged into groups in accordance with the geological province in which they are located, the upland soils being further separated on the basis of original vegetative cover. These groups are as follows:

Upland Prairie Soils, including the upland soils which have developed under a dominant grassland vegetation.



SOIL SURVEY MAP OF EDWARDS COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

TABLE 1.—SOIL TYPES OF EDWARDS COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils			
330	Gray Silt Loam On Tight Clay[1]	11.07	7 085	5.07
	Upland Timber Soils			
334	Yellow-Gray Silt Loam[1]	83.74	53 594	38.34
335	Yellow Silt Loam[1]	53.81	34 438	24.64
332	Light Gray Silt Loam On Tight Clay	1.52	973	.70
344	Yellow-Gray Fine Sandy Silt Loam	1.67	1 069	.77
345	Yellow Fine Sandy Silt Loam	1.86	1 190	.85
365	Yellow Sandy Loam	.10	64	.05
		142.70	91 328	65.35
	Terrace Soils			
1531	Deep Gray Silt Loam	9.74	6 234	4.46
1534.1	Yellow-Gray Silt Loam On Clay	8.02	5 133	3.67
1521	Drab Clay Loam[1]	7.71	4 934	3.53
1526.1	Brown Silt Loam On Clay	3.13	2 003	1.43
1564	Yellow-Gray Sandy Loam	.62	397	.28
1560	Brown Sandy Loam	.50	320	.23
1560.6	Light Brown Sandy Loam	.16	102	.07
		29.88	19 123	13.67
	Swamp and Bottom-Land Soils			
1331	Deep Gray Silt Loam	27.09	17 338	12.40
1354	Mixed Loam	7.08	4 531	3.24
1337	Yellow-Brown Silt Loam	.59	377	.27
		34.76	22 246	15.91
	Total	218.41	139 782	100.00

[1]This is the name under which the type was mapped. Later investigation has shown the desirability of making certain differentiations within the type; these are discussed under "Description of Individual Soil Types," beginning on page 19.

Upland Timber Soils, including nearly all the upland areas that are now, or were formerly, covered with forests.

Terrace Soils, including soils originally developed from material deposited by flowing water but which are now not subject to frequent overflow.

Swamp and Bottom-Land Soils, including the overflow land or flood plains along streams, the swamps, and the poorly drained lowlands.

Extensive field and laboratory study of soils has materially increased the knowledge of their characteristics since the time Edwards county was mapped. Thus the gradual accumulation of many new facts has made it possible to recognize, classify, and map soils upon a somewhat more comprehensive basis than formerly. A soil map of the county made at the present time would differ from the map presented here chiefly in showing a few more soil types, each having distinct characteristics and differing from one another in agricultural value as well as in treatment and fertilizer requirement. Several types, particularly Yellow-Gray Silt Loam, would now be divided into two or more types.

An inspection of the soils of this county was made just prior to the publication of this report, and in the section in which descriptions of the individual soil types are given (pages 19 to 33) the necessary modifications are described and discussed in such a way that it should not be difficult to recognize each new type in the field even tho it is not differentiated on the map.

For explanations concerning the classification of soils and further interpretation of the map and tables, the reader is referred to the first part of the Appendix, pages 34 to 36.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN EDWARDS COUNTY SOILS

Three Depths Represented by Soil Samples

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum, over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.
2. A middle stratum extending from 6⅔ to 20 inches and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling three zones for plant feeding are represented separately. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore it is the only stratum that can be greatly changed in composition as a result of adding fertilizing materials.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires to consider the information in that form. In comparing the different strata, it must be kept in mind that the composition of each is based on different quantities of soil, as indicated above. The figures for the middle and lower strata must be divided by two and three respectively before being compared with each other or with the figures for the upper stratum.

Wide Range in Organic Matter and Nitrogen

None of the soils in Edwards county contain very large amounts of organic matter and nitrogen. In fact the general deficiency of these constituents makes it particularly important that their increase be given first consideration in planning to care for the fertility of the soil. The rolling topography prevailing over much of the county contributes to the loss of much surface soil by erosion, and it is the surface soil where the greatest accumulation of organic matter and nitrogen occurs. The analytical results thus tend to emphasize

the need of preventive measures against erosion from the standpoint of saving the organic matter now present in the soil and that accumulated thru improved farm practices.

Without exception, the sandy types are among the lowest in the county in their content of organic matter and nitrogen. The decay of organic matter within the soil is essentially an oxidation process, the rate of which depends largely upon the air supply with which the organic matter comes into contact. Sandy soils being extremely well aerated are generally low in organic matter. Moreover it is a difficult problem to maintain organic matter in them. With them more than with any other type frequent plowing down of green manures and crop residues is needed unless stock-feeding operations make an abundant supply of farm manure obtainable.

The rapid decrease in organic matter and nitrogen in the lower levels of the soil may be observed by comparing Tables 3 and 4 with Table 2 after

TABLE 2.—EDWARDS COUNTY SOILS: PLANT-FOOD ELEMENTS IN UPPER SAMPLING STRATUM, ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300)							
330	Gray Silt Loam On Tight Clay	27 660	2 840	810	470	22 720	4 490	4 510
	Upland Timber Soils (300)							
334	Yellow-Gray Silt Loam	29 720	2 880	970	400	27 380	4 610	5 210
335	Yellow Silt Loam	18 210	1 740	620	360	31 890	5 470	4 700
332	Light Gray Silt Loam On Tight Clay	19 520	2 020	620	300	21 300	4 100	4 400
344	Yellow-Gray Fine Sandy Silt Loam	16 360	1 540	660	300	33 600	4 320	5 200
345	Yellow Fine Sandy Silt Loam	15 300	1 620	740	380	34 160	6 900	5 420
365	Yellow Sandy Loam	9 160	1 060	700	260	28 840	6 820	9 320
	Terrace Soils (1500)							
1531	Deep Gray Silt Loam	24 820	2 560	900	420	30 720	6 120	5 080
1534.1	Yellow-Gray Silt Loam On Clay	25 060	2 200	1 020	380	30 140	5 200	5 400
1521	Drab Clay Loam	42 210	3 660	1 090	610	37 200	13 870	15 050
1526.1	Brown Silt Loam On Clay	37 360	3 260	800	480	32 080	6 340	10 780
1564	Yellow-Gray Sandy Loam	19 040	1 740	960	280	29 400	6 960	10 740
1560	Brown Sandy Loam	32 200	2 900	680	240	28 620	5 400	10 400
1560.6	Light Brown Sandy Loam	16 900	1 480	860	240	28 540	5 220	13 100
	Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam	25 030	2 500	1 200	530	31 530	6 400	5 830
1354	Mixed Loam[1]							
1337	Yellow-Brown Silt Loam	20 340	1 940	1 040	380	36 580	11 480	13 240

LIMESTONE and SOIL ACIDITY.—In connection with these tabulated data, it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]The results of chemical analyses of Mixed Loam are not included on account of the heterogeneous character of this type.

correcting for the different thicknesses of the strata sampled, as explained on page 12. For example, Gray Silt Loam On Tight Clay, the first type listed, contains 27,660 pounds of organic carbon per 2 million of surface soil. In the second stratum the organic carbon content falls to 15,670 pounds per 2 million pounds of soil (one-half the value given in Table 3), while the lower stratum contains only 6,570 pounds per 2 million of soil (dividing by 3).

Phosphorus Content Generally Low

While some variation is to be observed in the total phosphorus content of the various soil types in Edwards county, the amounts present are in general rather low. This should not be taken to mean that phosphate fertilizers will necessarily bring good response at the present time but it does indicate that phosphate application may be expected to become necessary with continued cropping.

A convenient chemical test for use in the field has been recently devised at the Illinois Experiment Station which indicates the presence of available phosphorus in the soil and hence the relative need for phosphate treatment. Information concerning this test is furnished in Bulletin 337.

TABLE 3.—EDWARDS COUNTY SOILS: PLANT-FOOD ELEMENTS IN MIDDLE SAMPLING STRATUM, ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300)							
330	Gray Silt Loam On Tight Clay	31 340	3 580	1 380	680	50 600	14 720	8 440
	Upland Timber Soils (300)							
334	Yellow-Gray Silt Loam	25 510	3 010	1 520	540	58 360	14 860	8 060
335	Yellow Silt Loam	14 740	1 960	1 240	480	63 120	17 820	6 600
332	Light Gray Silt Loam On Tight Clay	23 520	2 520	1 040	400	42 880	7 760	8 080
344	Yellow-Gray Fine Sandy Silt Loam	13 520	1 040	1 520	420	68 000	17 320	10 440
345	Yellow Fine Sandy Silt Loam	11 560	1 720	1 840	440	71 560	20 920	11 160
365	Yellow Sandy Loam	7 120	1 000	1 360	120	59 520	7 480	26 240
	Terrace Soils (1500)							
1531	Deep Gray Silt Loam	24 520	2 800	1 440	640	61 600	12 080	11 000
1534.1	Yellow-Gray Silt Loam On Clay	16 480	2 000	1 520	440	63 840	11 960	8 560
1521	Drab Clay Loam	54 740	4 900	1 720	570	73 380	27 260	29 900
1526.1	Brown Silt Loam On Clay	47 440	3 880	1 200	560	64 800	19 280	19 120
1564	Yellow-Gray Sandy Loam	17 360	2 080	1 920	440	63 200	7 840	10 400
1560	Brown Sandy Loam	39 200	3 640	1 000	600	58 440	12 280	19 680
1560.6	Light Brown Sandy Loam	12 400	1 240	1 440	120	59 880	13 960	20 200
	Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam	19 600	2 240	2 020	510	61 820	12 080	9 160
1354	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1337	Yellow-Brown Silt Loam	27 240	3 000	1 920	600	73 920	23 680	26 000

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Results of chemical analyses for Mixed Loam are not included on account of the heterogeneous character of this type.

A part of the soil phosphorus is converted by growing plants from inorganic to organic combinations, with the result that a considerable portion of the phosphorus, especially of the surface soil, is organic. Investigations at the Illinois Station have shown that approximately 25 percent of the total phosphorus in the surface soil of Gray Silt Loam On Tight Clay, one of the types found in Edwards county, is organic. The phosphorus which is thus converted into organic form is in part obtained from the lower strata and left in the surface, with the result that the surface soil usually contains slightly more of this element than is found in the middle and lower strata, as may be observed by a comparison of Tables 2, 3, and 4.

Sulfur Returned to Soil in Rainfall

There is some degree of correlation between the amounts of sulfur and organic carbon found in the soil. This is because a considerable tho varying proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of organic matter. The soils of Edwards county contain on the whole less than one-half as much sulfur as phosphorus, the amount in the sur-

TABLE 4.—EDWARDS COUNTY SOILS: PLANT-FOOD ELEMENTS IN LOWER SAMPLING STRATUM, ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (300)							
330	Gray Silt Loam On Tight Clay	19 710	3 090	1 590	630	78 930	22 590	15 720
	Upland Timber Soils (300)							
334	Yellow-Gray Silt Loam	16 070	2 570	1 950	480	90 150	31 200	14 640
335	Yellow Silt Loam	13 050	1 950	1 740	570	86 790	21 900	10 650
332	Light Gray Silt Loam On Tight Clay	18 780	3 000	1 500	480	66 780	20 640	12 900
344	Yellow-Gray Fine Sandy Silt Loam	12 300	1 320	2 400	300	112 500	36 000	19 860
345	Yellow Fine Sandy Silt Loam	10 440	1 740	2 340	360	101 100	28 380	26 340
365	Yellow Sandy Loam	10 320	1 320	2 940	240	94 560	13 320	34 980
	Terrace Soils (1500)							
1531	Deep Gray Silt Loam	27 300	3 300	1 920	840	93 480	21 960	15 540
1534.1	Yellow-Gray Silt Loam On Clay	18 120	2 580	2 040	480	96 420	28 560	13 740
1521	Drab Clay Loam	39 090	4 380	2 400	870	110 730	47 100	44 400
1526.1	Brown Silt Loam On Clay	34 320	3 660	2 160	600	105 540	45 240	42 000
1564	Yellow-Gray Sandy Loam	15 660	2 100	2 820	120	91 080	13 440	25 860
1560	Brown Sandy Loam	37 500	3 900	2 040	660	93 540	15 300	28 560
1560.6	Light Brown Sandy Loam	12 120	1 740	2 580	420	91 140	16 860	30 960
	Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam	18 090	2 460	2 610	510	94 380	22 350	13 920
1354	Mixed Loam[1]	.....	.....	.....	.....	.....	.....	.....
1337	Yellow-Brown Silt Loam	31 680	4 080	3 060	960	115 020	34 560	32 520

LIMESTONE and SOIL ACIDITY.—See note in Table 2.

[1]Results of chemical analyses for Mixed Loam are not included on account of the heterogeneous character of this type.

face soil ranging from 240 to 610 pounds an acre. Like phosphorus, the sulfur content generally decreases with depth, partly because some of the sulfur is in combination with organic matter, which decreases with depth, and partly because organic sulfur is less subject to leaching than calcium sulfate (gypsum), the chief inorganic form of sulfur found in soils.

The sulfur available to crops is affected not only by the supply in the soil, but also by the amount brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water, and consequently is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption the amount of sulfur thus added to the soil is relatively large. At Urbana during the eight-year period from 1917 to 1924 there was added to the soil by the rainfall an average of 3.5 pounds of sulfur an acre a month. Similar observations have been made in other localities for shorter periods. The precipitation at the various points in the state in a single month has been found to vary from a minimum of three-fourths of a pound to more than ten pounds an acre.

These figures afford some idea of the amounts of sulfur added by rain, and also of the wide variations in quantity under different conditions. Considering the amounts which are brought down in rainfall in addition to the soil supply, the facts would indicate that apparently there is little or no need for sulfur fertilizers in Edwards county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum are being conducted on a number of experiment fields in various parts of Illinois.

Potassium Content Relatively Uniform Thruout County

The potassium content of the various types exhibits less variation than any other element studied. It ranges in the surface soil from 21,300 pounds an acre in Light Gray Silt Loam On Tight Clay to 37,200 pounds in Drab Clay Loam. It will be noted, also, that the concentration of potassium remains practically constant thruout the entire depth which has been sampled and analyzed.

Calcium and Magnesium Vary Widely

Soils in general exhibit wide variations in the content of calcium and magnesium, and Edwards county is no exception to this rule. In the surface soil, magnesium varies from 4,100 pounds an acre to 13,870 pounds, while calcium varies from 4,400 pounds to more than 15,050 pounds. The presence of calcium in amounts of this magnitude is no indication that the soil may not need liming. In acid soils fairly large amounts of calcium are to be found. Much of it is locked up, however, by combination in silicate minerals, which decompose so slowly that calcium is not liberated in sufficient quantities to maintain a neutral reaction or to supply the calcium needs of growing crops.

Soils recently formed from young soil materials very frequently contain calcium carbonate (limestone) even in the surface stratum. Since calcium carbonate is readily soluble in soil water, it gradually leaches downward to

greater and greater depths. Thus in no case do we find calcium carbonate in the surface soil in Edwards county, and only two soil types—Brown Silt Loam On Clay, Terrace, and Yellow-Brown Silt Loam, Bottom—were found to contain it in the lower sampling stratum.

In the noncarbonate upland soils, variations in the amounts of calcium and magnesium at the different depths give some indication of the movement of these elements in soil formation. In the surface soil the calcium usually exceeds the magnesium in amount, either as a result of the preponderance of calcium in the soil-forming materials or as a result of plant growth. In the second stratum (6⅔ to 20 inches) we find the magnesium content gaining on the calcium and equalling or exceeding it in most cases, while in the lower stratum sampled the magnesium exceeds the calcium in every upland type but one, being much more abundant than near the surface. The calcium content, on the other hand, is but slightly higher or even lower in most cases in the lower depths as compared with the surface soil.

It is significant that this divergence in amounts of calcium and magnesium with increasing depth is increasingly pronounced in the more-mature types. These variations may be explained as due to the greater leachability of the calcium as compared with magnesium or to reabsorption of magnesium in the lower strata.

Local Tests for Soil Acidity Often Required

It is impracticable to attempt to obtain an average quantitative measure of the calcium carbonate content or the acidity of most soil types because, while some samples will contain large amounts of calcium carbonate, others will contain none or may actually have a lime requirement due to the soil acidity. We thus have what may be considered positive and negative values ranging, perhaps widely, on the opposite sides of the zero or neutral point, the numerical average of which could have no significance whatever, since such an average would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the accompanying tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types. The qualitative field tests made in the process of the soil survey are much more numerous than the chemical analyses made in the laboratory, and they give a general idea of the predominating condition in the various types as to acidity. These tests, therefore, furnish the basis for some general recommendations which are given in the descriptions of individual types on pages 19 to 33. To have a sound basis for the application of limestone the owner or operator of a farm must usually determine individually the lime requirements of his different fields. The section in the Appendix dealing with the application of limestone (page 41) is pertinent and should be read in this connection.

Supplies of Different Elements Not Proportional to Crop Removal

In the foregoing discussion we have considered mainly the amounts of the plant-food elements in the surface 6⅔ inches of soil, and rather briefly the relative amounts in the two lower strata. We have noted that some of the ele-

ments of plant food exhibit no consistent change in amount with increasing depth. Other elements show more or less marked variation at the different levels, the trend of these variations serving in some cases as clues to the relative maturity of different soils and the processes involved in their development.

By adding together the corresponding figures for all three strata, we have an approximate invoice of the total plant-food elements within the feeding range of most of our field crops, since the major portion of their feeding range is included in the upper 40 inches. One of the most striking facts brought out of this consideration of the data is the great variation within a given soil type in the relative abundance of the various elements present as compared with the amounts removed by crops. In one of the important types in the county—Gray Silt Loam On Tight Clay, Upland—we find that the total quantity of nitrogen in all three strata is 9,510 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus is a little over one-third as much, or 3,780 pounds, but this amount is equivalent to the phosphorus in about two and one-half times as much corn, namely, 22,200 bushels. In the surface stratum, however, which is the zone of most intensive crop feeding, we find the relative amounts of nitrogen and phosphorus more nearly in accord with the rate of removal of these elements by crops. Here the nitrogen is equivalent to 2,800 bushels of corn, and the phosphorus to 4,700 bushels, or somewhat less than twice the nitrogen equivalent.

Other types show marked contrast to Gray Silt Loam On Tight Clay, just discussed, with respect to total content in relation to rate of removal by crops. However, in most soils, except those which are peaty, phosphorus is more abundant than nitrogen when considered in terms of crop equivalents rather than as an absolute amount.

Service of Chemistry in Soil Investigation

The foregoing discussion should not be taken to mean that it is possible to predict how long any certain soil could be cropped under a given system before it would become exhausted. Nor do the figures alone indicate the immediate procedure to be followed in the improvement of a soil. It must be kept in mind that the *amount* of plant food as determined by the chemical methods in vogue fails, of itself alone, to measure the ability of a soil to produce crops. The *rate* at which these elements are liberated from insoluble forms and converted to forms that can be used by growing plants is a matter of at least equal importance, as explained on page 39, and is not necessarily proportional to the total stocks present. One must know, therefore, how to cope with the peculiarities of a given soil type if he is to secure the full benefit from its stores of the plant-food elements. In addition, there are always economic factors that must be taken into consideration, since it is necessary for one to decide at how high a level of productive capacity he can best afford to maintain his soil.

The chemical soil analysis made in connection with the soil survey is seen to be of value chiefly in two ways. In the first place, it reveals at once outstanding deficiencies or other chemical characteristics which alone would affect

its productivity to a marked extent, or point the way to corrective measures. It should be borne in mind, however, that fairly wide departures from the usual are necessary before the chemical analysis alone can be followed as a guide in practice without supplementary information from other sources. An example of the direct use of the results of chemical investigations is the marked shortage of potassium in peat soils associated with the need for potassium fertilizers. Another case is the determination of the lime need of soils by chemical tests. It is probable that the results of chemical soil analyses are frequently misused by attempting to interpret small differences in the amount of a certain plant-food element as indicative of fertilizer needs. For example, differences of 100 or 200 pounds of phosphorus per acre in soils containing 1,000 pounds or thereabout in the surface soil should not be considered of any significance as to the probable response of the soil to phosphate fertilization. Or, for example, in the case of nitrogen, where the ordinary chemical analysis does not distinguish between active and inactive forms, 100 pounds of active nitrogen added to the soil by plowing down a crop of clover may be of more importance to the succeeding crop than 1,000 pounds of soil nitrogen, only a small part of which may be in a form that plants can use.

The second function of soil analysis is to aid in the scientific study of soils from many angles, the ultimate aim of which is, of course, the more economical utilization of the soil for efficient crop production. Not only do chemical studies aid in determining the processes involved in soil development under natural conditions, but also in determining the effects of different soil management and fertilizing practices upon the soil and upon the utilization by crops of the plant-food elements involved.

DESCRIPTION OF SOIL TYPES

In the following descriptions of individual soil types an effort is made to describe the types as they would be mapped at the present time. It will be observed that several of the types as they appear on the soil map are now acknowledged to include two or more types. The situations in which these new types occur, particularly the topographic positions, are so stated that, in most cases, the soils can easily be recognized in the field even tho not differentiated on the accompanying map.

UPLAND PRAIRIE SOILS

The upland prairie soils of Edwards county occupy 11.07 square miles and are confined to relatively small, isolated areas. All the prairie land which occupies a true upland position is located on a remnant of the original plain which now appears as a flat-topped ridge one to three miles wide running in a northeast-southwest direction across the north-central part of the county. The settlement of Samsville is located on this ridge. The reason for the existence of even isolated areas of prairie soil on the present upland in this section of the state remains debatable. Normally, forests invade the land, particularly in a country where the temperature and rainfall are so nearly optimum for the development of forest vegetation as here. This prairie condition may be

due to some accidental cause, such as forest fires continually nipping the new growth; or it may be due to poor drainage conditions hindering the rapid advance of the forest. The prairie land is relatively flat, and prior to artificial drainage was probably saturated with water or even covered with shallow lakes or ponds during a portion of each year. These shallow ponds were probably dry only in late summer and autumn, at most not more than a few months each year. Forest vegetation would have difficulty in making a start in a soil which remained water-logged most of the year, whereas prairie grass, which matures in a relatively short time, could make some growth during each dry season. The establishment of a thick grass sod on the ground would further impede forest advance by making it difficult for the seeds to take root in the soil.

The remaining portion of the area mapped as upland prairie soil occupies a position on bench lands or terrace formations. These areas occur as isolated patches just above the overflow areas along some of the major stream courses. They were built up very largely from slope wash accumulated from surrounding higher land. Some wash is still being deposited on them following heavy rains. Their position at the base of slopes makes them subject to seepage. Under these conditions the soils have been unable to reach the stage of development of those on the upland. The characteristics of these soils resemble those of the upland prairie, and indications are that their development is in the same direction as that of soils on the true upland. They are spoken of as youthful prairie soils in the sense that they are not as yet maturely developed.

The upland prairie soils of Edwards county range in color from brownish gray to gray in the surface stratum, owing to variation in the amount and condition of the organic matter. The surface color of the prairie soils is darker than that of the timbered soils because the decayed vegetable material derived from the prairie grass that once grew on them was protected from rapid oxidation. Undoubtedly these soils were at one time as dark and fertile as those of central Illinois today, but because of their great age, acidity, and loss of mineral plant food, the common prairie soils in southern Illinois have become incapable of supporting a luxuriant plant growth.

Gray Silt Loam On Tight Clay (330)

All the upland prairie soils of Edwards county were formerly classified as Gray Silt Loam On Tight Clay and appear as such on the accompanying map. This type is now recognized however to include several types, each having definite characteristics, and each of which is associated with a characteristic topographic expression. The original name, Gray Silt Loam On Tight Clay, has been retained for the designation of one of these types and new names applied to the others. The new names adopted are Deep Gray Silt Loam On Tight Clay and Gray Silt Loam On Orange-Mottled Tight Clay.

Deep Gray Silt Loam On Tight Clay. This type occurs almost entirely on the bench land or terrace formations. A few small areas are found in small depressions at the heads of drainage courses or at the base of gentle slopes in the upland. This type was originally poorly drained and swampy, much of

it having been covered by a growth of brush with a few swamp oak. It has received, and in many places is still receiving, a silty wash brought down as a result of sheet erosion from adjoining higher land. Some of it has been artificially drained by a system of surface ditching which tends to divert the water that formerly flooded the land. Its topography is nearly level with usually a very gentle slope toward the bottom land.

The surface soil of this type varies from 6 to 11 inches in thickness and is a brownish gray, friable silt loam. Small rounded iron pellets are frequently found lying on top of the ground. The subsurface soil is friable, gray, and rather thick. Below 16 inches and above the subsoil the subsurface material is usually light gray and ashy. The subsoil begins at depths varying from 22 to 30 inches, depending upon the rate at which material is being deposited on the surface. Other characteristics of the subsoil are largely dependent upon the rate of surface deposition. It varies from a thick, yellowish gray, compact, plastic clay in areas where little or no material is deposited to a relatively thin, grayish yellow, medium-compact and plastic clay loam where deposition is frequent. Below 40 to 50 inches the material in the lower subsoil becomes more friable and usually more sandy.

Management.—Deep Gray Silt Loam On Tight Clay can be so managed as to return a moderate yield on the investment. The first defect to be corrected in the management of this type is poor drainage. Some means must be provided to keep run-off water from covering the land. This can most effectively be done by running a deep, open ditch from the bottom land to the source of overflow. Following that, a system of either shallow surface ditches or tile must be provided to remove the excess water which accumulates from the rainfall. Tile are of little value unless they can be laid above the compact subsoil. Only in those areas where the subsoil is at least 24 or more inches below the surface should tile drainage be employed. Tile should be placed not more than 4 to 6 rods apart. Shallow, open ditches should be 3 to 4 rods apart.

This soil is acid and is low in organic matter. The next step in increasing its productivity is to apply enough limestone to sweeten the land, after testing each field in detail. Clover, preferably sweet clover, should be included in the rotation. Plowing under clover will correct the nitrogen deficiency and add active organic matter. Clover should be grown and plowed under every third or fourth year. After the acidity and nitrogen deficiency have been corrected, trials of phosphate and potash fertilizers are suggested. A trial application is suggested because there are no definite data to indicate possible results. The system of crop rotation, chosen from the list suggested in the Appendix (page 49) which most nearly meets the needs of a particular situation should give a fair return on this soil provided it is properly managed.

Gray Silt Loam On Tight Clay. This type is found on the flat uplands and in the center of some of the areas which occur as bench lands and terraces. Only a very small portion of the total prairie soil area would now be mapped as this type. Its chief characteristic is a thick, very compact and plastic subsoil which makes water movement thru the soil very slow. It is wet in spring because it lies too flat for water to drain off the surface and the tight subsoil

prevents underdrainage. It is drouthy in late summer because moisture cannot move up to the surface from below.

The surface soil is about 8 inches thick and is a friable, light brownish gray silt loam. The first 5 or 6 inches of the subsurface is a gray silt loam, and the lower 5 to 7 inches is a very light gray, ashy silt loam. The subsurface is separated by a sharp line from the subsoil, which is a dark gray, very compact and plastic clay. A pale red or orange mottling often occurs in the upper few inches of the subsoil, which is encountered at depths varying from 18 to 22 inches. This tight, sticky subsoil is rather thick in the original upland areas, often 3 feet or more. Sand and small rounded pebbles begin to appear below 40 inches but they do not seem to have any effect on its imperviousness. The subsoil of this type developed on bench lands or terraces is neither so tight nor so thick as that in the upland, seldom being over 20 inches.

Management.—Since it is practically impossible to drain this type adequately, it is questionable how much treatment can be given with profit. Tile will not draw, and open surface-ditching is the only means of drainage. This however is not effective unless a good outlet can be established. The soil is very acid. Following liming it will grow sweet clover but not alfalfa. Any additional fertilizer treatment should be limited at first to a trial basis. Corn should probably not be grown, but hay, particularly red top, can be included in a rotation with sweet clover and a small grain. Even under the best of management, only a small rate of return can be expected from this land.

Gray Silt Loam On Orange-Mottled Tight Clay. This type is found almost entirely in the upland. It occurs on gently rolling areas and has fair natural drainage. The plots of Series 100 on the West Salem soil experiment field are located on land very similar to this type.

The surface soil is 6 to 7 inches thick, and is a friable, brownish gray silt loam. The subsurface is yellowish gray in the upper part and gray with pale red or orange mottling in the lower part. The subsoil begins at 14 to 18 inches and is a dark gray, profusely orange-mottled, very compact and plastic clay. The lower subsoil below 24 to 26 inches is yellowish gray in color and not so compact or plastic as the upper. Some sand and small pebbles occur in the lower subsoil.

Management.—Altho this type cannot be successfully tile-drained, it has enough slope so that shallow open surface-ditching, if the ditches are placed 2 to 3 rods apart, will remove most of the excess surface water. It is extremely acid, a condition which can be corrected by applying limestone. Before liming, each field should be tested in detail to learn the amount required to neutralize the acidity. Following liming, clover should be grown and turned under. The results from the plots in Series 100, West Salem field (see Supplement, page 52), indicate that the application of phosphate and potassium fertilizers with limestone and organic matter substantially increase the yield. It should be kept in mind, however, that even after full treatment is applied, only fair crop yields are returned and complete crop failures sometimes occur.

Slick Spots

Slick spots are peculiar soil formations which occur within all the above-described prairie soil types, and they are also found in association with Yellow-Gray Silt Loam On Tight Clay and Light Gray Silt Loam On Tight Clay (upland timber soils), as well as with Deep Gray Silt Loam (a terrace soil). These spots are not shown on the map since they usually are small. They can be easily identified, however, by the extremely light color of the surface soil. They are commonly called "scalds" or alkali spots. They usually occur in small areas 50 to 100 feet in diameter, altho occasionally a larger area covering as much as 20 to 30 acres is found.

Slick spots are found in regions of relatively flat topography where a shallow deposit of soil material has accumulated over an impervious substratum. The leaching and removal of chemical bases from the superimposed material that would naturally take place was interrupted in these areas by the slowly pervious material below, and the leached bases were thrown out of solution, accumulating as salts and concretions such as magnesium sulfate and calcium carbonate. This accumulation of chemicals made the soil highly alkaline and produced an excess of salts which acted either to unbalance the plant-food situation or even to prohibit plant growth. Vegetation on these spots is either stunted or completely lacking and only in the most favorable years is any crop harvested from them.

The surface soil varies in thickness from 2 to 7 or 8 inches and in color from very light gray to gray. It is always lighter in color than the surrounding soil. The subsurface is usually very thin, is light gray in color, and contains many black, rounded pellets. The subsoil begins at 8 to 16 inches and is sharply differentiated from the overlying material. It has a peculiar greenish-yellow color, and when exposed and dry stands out in characteristic columnar form, over which a white salty material accumulates. It is extremely hard and tough when dry but offers little resistance to pressure when wet. It takes up water very slowly when thoroly dry, but absorbs it readily when wet. Many bad mud holes develop on the roads which run thru these spots, and in cultivated fields the toughness of the subsoil forces the plow to the surface.

Management.—Little is known about the management of slick spots. Most of these areas will grow sweet clover without treatment. If the surface soil is acid, as is sometimes the case, a light application of limestone must be made. Until such time when treatment can be applied, it is suggested that a legume such as sweet clover be grown in so far as this is possible. Practical experience has shown that the application of animal manure gives relatively small returns on these spots.

UPLAND TIMBER SOILS

Forests have overspread at one time or another more than nine-tenths of the upland area in Edwards county. The upland timber soils, as mapped, occupy 142.70 square miles, about two-thirds of the total area of the county. These soils are characterized by a yellow to yellowish-gray color which is due to their low organic-matter content. This lack of organic matter is the result

of the growth of forest trees over long periods of time. As the forests invaded the prairies, the following effects were produced: the shading of the trees prevented the growth of grasses, the roots of which are mainly responsible for the large amount of organic matter in the prairie soils; and the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed or were completely destroyed by forest fires. Much of the original timber in the county has been cut off and the areas cleared and cultivated, but the soil still retains the effects left by the long-continued forest growth. Japanese clover, or lespedeza, a legume which will grow in an acid soil, has spread over the timber soil in this region. It affords some pasture but is particularly beneficial in retarding erosion on cleared, uncultivated areas by checking run-off.

The same situation with respect to differentiation of types exists in the upland-timber soil group as was noted for those in the upland-prairie soil group, in that each type shown on the soil map would now be separated into two or more types. These new separations will be described in order as they correlate with the types shown on the map.

Yellow-Gray Silt Loam (334)

Yellow-Gray Silt Loam as mapped occupies 83.74 square miles, nearly 40 percent of the total area of the county. It includes three types, each of which is associated with a characteristic topographic expression. These types are named: Yellow-Gray Silt Loam On Tight Clay, Yellow-Gray Silt Loam On Compact Medium Plastic Clay, and Reddish Yellow-Gray Silt Loam.

Yellow-Gray Silt Loam On Tight Clay. This type occurs on flat or very gently sloping land. Most of it is confined to the flat areas between Fox and Sugar creeks in the northwest part of the county. Small areas of it surround some of the land mapped as upland prairie on bench-land formations. Both the surface drainage and underdrainage of this type are poor. Slick spots occur frequently. In many respects this type resembles the prairie type Gray Silt Loam On Tight Clay.

The surface soil is 4 to 5 inches thick and is yellowish gray in color. Cultivation, by mixing the surface with the subsurface, has thickened this surface stratum and has also lightened its color. The upper subsurface is gray in color, and the lower subsurface ashy white. Except for being somewhat more yellowish in color, the subsoil of this type is similar to that of Gray Silt Loam On Tight Clay.

Management.—For suggestions regarding the management of this soil the reader is referred to the management discussion of Gray Silt Loam On Tight Clay (page 22). Better drainage can usually be secured in this type than in its corresponding prairie type because this type lies closer to an outlet. The plots of Series 200 and 300 on the Raleigh field are located on soil similar to this type and should be studied in this connection (see pages 60 to 62).

Yellow-Gray Silt Loam On Compact Medium-Plastic Clay. More than half the area shown on the map as Yellow-Gray Silt Loam would now be

classified as Yellow-Gray Silt Loam On Compact Medium-Plastic Clay. It is the predominant upland type in the central and northern parts of the county. This type is found on the intermediate slopes in the upland. It has fair to good surface drainage and fair subsurface drainage.

The surface soil is 6 to 7 inches thick. The color of the virgin soil is brownish yellow, but following continued cultivation it changes to yellowish gray. The subsurface is friable and is yellowish gray in color. Just above the subsoil the subsurface is a pale yellowish gray and slightly resembles the gray layer so characteristic of soils developed on flat topography under poor drainage. The subsoil begins at 15 to 18 inches and is a moderately compact, somewhat plastic clay loam, grayish yellow in color. The lower subsoil below 32 to 40 inches is often more friable than the upper. Sand and small pebbles frequently occur in the subsoil of this type in the northern part of the county.

Management.—Yellow-Gray Silt Loam On Compact Medium-Plastic Clay is one of the best upland soils in Edwards county. It has been mistreated by farmers in the past, robbed of its fertility, and then in the face of erosion left without a protective cover. At present not much of this type is very productive, but it has possibilities of improvement. Better drainage should be provided by artificial means. Tile will not draw for any great distance and will not carry excess water away swiftly, but in the spring they will often make a difference of 10 to 15 days in the time when the soil becomes dry enough for cultivation. A system of shallow surface ditches should be provided to collect and carry off the water in order to prevent excessive slope wash. These ditches should be constructed in such a way as to carry off the water slowly and not to allow deep gullies to develop. To prevent surface wash on the more sloping areas, shallow terraces should be constructed following the contours. A crop or vegetative cover should be kept on the land during the winter and spring as a further protection against sheet-washing.

The soil is acid and in need of nitrogen and organic matter. Limestone should be applied in amounts needed to sweeten the land, and then a legume, preferably sweet clover, seeded and turned under. This practice will correct the nitrogen deficiency and furnish active organic matter, thus enriching the soil as well as putting it in better physical condition. The results obtained on the plots of Series 100 on the Enfield experiment field, which are located on this soil type, indicate that the use of some potassium fertilizer would pay if used on land on which sweet clover had been turned under (see page 63).

Reddish Yellow-Gray Silt Loam. This type occurs on the rolling upland and is confined to the central and southern parts of the county. It has developed under good natural drainage on rolling, preglacial topography. The natural slope of the land has given erosion a better chance to remove the loose soil where the protective timber cover is cleared off. Much of this soil type, particularly in the southern part of the county, is badly gullied and sheet-washed. It takes only a few years of exposure to erosion to reduce this soil to a state of unproductiveness.

The surface of the virgin soil of this type is 6 inches thick and is brownish yellow in color. Following a few years of cultivation the color changes to

yellow. The subsurface is friable and its color is yellow with a reddish cast. The subsoil begins at 11 to 15 inches and is a slightly compacted, non-plastic, silty clay loam, reddish yellow in color. The subsoil gradually becomes more friable below 25 inches. It maintains the yellow color but loses the reddish cast and thin streaks of gray appear.

Management—Reddish Yellow-Gray Silt Loam is potentially one of the best upland soils in Edwards county. It is largely unproductive at present because of gross mismanagement. It is naturally well drained but must be protected against destructive erosion. With additions of fresh organic matter the soil will absorb water faster. A protective vegetative cover should always be kept on the land during winter and early spring. This soil type will respond to terracing probably better than any of the other types mentioned. Circular 290 of the Illinois Agricultural Experiment Station is suggested as a source of information on the details of soil terracing.

This type is acid but not strongly so. A moderate application of limestone will usually sweeten the soil for sweet clover growth. Several crops of clover should be grown and turned under to add nitrogen and organic matter. The application of phosphate on land of this type which has been previously built up by limestone and legumes would probably pay. The results obtained from the Elizabethtown and Unionville fields, which are located on soil resembling this type, corroborate this statement. Potassium used in addition to phosphate does not give significant increases (see pages 64 to 67). The application of manure has given very beneficial results, and probably as much return can be obtained per ton when applied on this type as on any other in the county.

Reddish Yellow-Gray Silt Loam will grow alfalfa after lime has been applied and manure or a legume crop turned under. It is not particularly adapted to growing corn because of the lack of sufficient moisture during the ripening of the crop. It is better suited to winter and spring small grains, cowpeas, soybeans, and special crops such as vegetables and fruits. Most of the successful peach orchard sites are located on this type. Information relative to the treatment of the soil for special crops may be obtained by writing direct to the Agricultural Experiment Station.

Yellow Silt Loam (335)

Yellow Silt Loam as mapped occupies 53.81 square miles, nearly 25 percent of the total area of the county. Properly, it includes two types: Reddish Yellow Silt Loam, and Yellow Silt Loam. These types occur on very rolling to rough topography and are subject to destructive erosion.

Reddish Yellow Silt Loam. This soil type is found only in the central and southern parts of the county on the very rolling to steep slopes. It has developed in the region of preglacial topography and has been protected from devastative erosion by a vegetative cover. Under cultivation the soil is soon washed away and the land made unproductive unless properly managed.

The surface of the virgin soil of this type is 4 to 5 inches thick, friable in texture and brownish yellow in color. Cultivation changes the surface color to reddish yellow. The subsurface is thin, friable, and reddish yellow. The

subsoil begins at 8 to 11 inches, and is a non-plastic, only very slightly compacted, reddish yellow silt loam. The lower subsoil is even more friable than the upper and is yellow in color.

Management.—Reddish Yellow Silt Loam is not adapted to general grain farming. Following treatment such as suggested for Reddish Yellow-Gray Silt Loam it can be utilized for growing alfalfa, winter small grains, vegetables, fruits, or put in permanent pasture or vineyard. The success of any project on this type of soil depends largely upon the prevention of erosion. Terracing and keeping the soil under a vegetative cover during the rainy seasons and the frequent addition of fresh organic matter are the means by which this can be accomplished. The reader is referred to the discussion of results on the Elizabethtown field, which is located on soil similar to this type (see page 64).

Yellow Silt Loam. This type is found on the steep gullied slopes thruout the county. In the northern part of the county it is found in the steep gullies which break abruptly from the flat upland. Most of these gullies have never been cleared of timber. In the southern part of the county Yellow Silt Loam occurs in patches on the steep hillsides of preglacial ridges as well as along the small bottom lands. Most of the small patches are the result of recent erosion following clearing of the timber from the land. Occasional outcrops of sandstone and shale rock are found in this type.

Yellow Silt Loam has little or no soil development because the surface is removed faster than the soil forms. The gullies along small streams in the northern half of the county are sandy and gravelly. Erosion has exposed the boulder clay deposited by the glacier. The eroded areas in the southern half of the county are usually silty, being the lower deposits of the loess.

Management.—The Yellow Silt Loam in the northern part of the county cannot be cultivated because of its steepness of slope. It should be used for forestry. Some of that in the southern part may be built up in the manner suggested for Reddish Yellow Silt Loam and used as permanent pasture or orchards. Present conditions do not warrant the expenditure of much money in its development in view of the fact that there is a large acreage of better land in and surrounding the county which is not fully utilized. Perhaps it should be reforested at present and held in reserve until some future time when the agricultural economic situation demands its return to cultivation.

Light Gray Silt Loam On Tight Clay (332)

Light Gray Silt Loam On Tight Clay occurs on the very flat, exceptionally poorly drained, depressional areas in the northern half of the county. It is found on the remnants of the upland plain. A few areas of this type are mapped on the flat land between Sugar and Fox creeks in the northwestern part of the county. These areas more nearly resemble Yellow-Gray Silt Loam On Tight Clay, and the reader is referred to the discussion of that type (page 24) for information concerning these areas. Typical Light Gray Silt Loam On Tight Clay has very poor surface drainage and underdrainage. During wet weather the soil is soft and mushy, while in dry weather it bakes and becomes very hard. The areas of this type are spoken of as "post oak" or "hickory

flats'' because of the kind of timber which once grew on them. Black pellets, known as ''buckshot,'' are abundant over the surface of this soil.

The surface of the virgin soil is 2 to 3 inches thick and is brownish gray in color. Cultivation has mixed some of the gray subsurface material with the surface and furthered organic-matter decay so that the surface soil in plowed fields of this type have a pale yellowish color. The upper subsurface is gray and the lower subsurface ashy white. Both the surface and subsurface contain numerous small, rounded black pellets. The subsoil is thick, very tough and hard when dry and sticky when wet. Water penetrates it very slowly and it is termed an impervious clay.

Management.—Fortunately the total area of this type in the county is small, for this is the poorest of all the soils. It cannot be successfully drained, it is extremely acid, very low in organic matter, and generally unproductive. Altho it is not well adapted to pasture land or meadow, that seems to be the best possible use for it. (See account of Sparta field experiments, page 62.)

Yellow-Gray Fine Sandy Silt Loam (344)

Yellow-Gray Fine Sandy Silt Loam occupies a total area of 1.67 square miles in Edwards county and is all found within three miles of Grayville. This soil resembles Reddish Yellow-Gray Silt Loam, differing from it in having a thicker surface soil and one that is coarser in texture. The upper soil material of this soil type was deposited as loess considerably later than that covering most of the county. It is therefore a younger, less-leached, and more-productive soil. It lies on rolling topography and is well drained.

The surface soil varies from 8 inches in thickness along the west border of the area to 12 inches near the Wabash river bluffs. It is brownish yellow in color, very friable, and of a coarse, silty texture. The subsurface and subsoil are very similar to those of the Reddish Yellow-Gray Silt Loam.

Management.—In favorable years this soil will grow red clover without lime. It takes only 1½ to 2 tons of limestone to sweeten it in order to grow sweet clover or alfalfa. The same management practices should be used on this type as those suggested for Reddish Yellow-Gray Silt Loam (see page 25). Somewhat better returns can be expected because it is naturally a more-productive type.

Yellow Fine Sandy Silt Loam (345)

Yellow Fine Sandy Silt Loam occupies 1.86 square miles in Edwards county and occurs as the more-rolling to steep phase of Yellow-Gray Fine Sandy Silt Loam. With the exception of having a darker and coarser surface soil, this type is similar to Reddish Yellow Silt Loam; it is also more youthful and more productive. With these exceptions in mind the reader may refer for the description and management of this type to the discussion of Reddish Yellow Silt Loam, page 27.

Yellow Sandy Loam (365)

One area, 64 acres in extent, of Yellow Sandy Loam, located just west of where Bon Pas creek enters the Wabash river, was mapped in Edwards county.

This area has dune-like topography and lies considerably lower than the upland but higher than the surrounding terrace land. The type is formed from a deposit of 10 to 30 feet of medium to coarse sand resting on limestone bedrock.

Yellow Sandy Loam has a shallow, brownish-yellow sandy-loam surface soil. Below 6 to 8 inches the soil becomes sandy and yellow in color. At 20 to 25 inches a reddish cast appears, and this is accompanied by a slight compaction. Below 30 inches the material becomes loose and very sandy.

Management.—This soil is slightly acid but with a small application of limestone will grow excellent clover and alfalfa. Wheat usually produces a good crop. Corn is an uncertain crop because of the drouthy nature of the soil. However, in years of favorable moisture supply a good corn crop can be produced. The available information from experiment fields indicates that limestone with manure or legumes is the most profitable treatment.

TERRACE SOILS

The terrace formations in Edwards county were made during or shortly after glacial times by overloaded and flooded streams which deposited an immense amount of material in the old channels. Later as the streams diminished in size and cut their channels deeper, new bottom lands were developed, leaving the old flood plains above overflow except in high flood stages. The soils on the terraces mapped along Bon Pas creek and Wabash river appear to be younger than those along Little Wabash river. The soil material from which the terraces were formed was for the most part washed down stream from above. That along Bon Pas creek was probably mixed more or less with sediment from Wabash river back water and kept under water or in a marshy condition longer than that along Little Wabash river.

Deep Gray Silt Loam (1531)

Deep Gray Silt Loam, Terrace, occupies 9.74 square miles and is found along all the principal streams in the county. It is derived very largely from more or less recent wash accumulating from the immediately surrounding upland. Most of the areas of this type have a flat topography and lie in such a position adjacent to the upland as to receive considerable run-off. Drainage is often difficult on account of the considerable distance to a stream channel. Many of the areas are wet in the spring and early summer.

This type has a dark gray silty surface soil varying from 6 to 12 inches in thickness. There is little or no soil development below the surface; the soil gradually becomes lighter in color without much change in texture or compaction with increasing depth. Occasionally on slightly higher land a thin, somewhat compact and plastic band occurs in the soil at a depth between 20 and 30 inches. Black, rounded pellets are abundant on top and thru the soil.

Management.—The reader is referred to the discussion of Deep Gray Silt Loam On Tight Clay (page 21) for suggestions regarding the management of this terrace type.

Yellow-Gray Silt Loam On Clay (1534.1)

Yellow-Gray Silt Loam On Clay occupies a total area of about 8 square miles in Edwards county. Most of it lies adjacent to the Bon Pas and Little Wabash stream channels. The soil material from which this soil developed was deposited as alluvium during high water. The areas of this type do not overflow at present except during high flood stages of the Wabash river. At these times the outlets of smaller streams are blocked and back water from them covers the area of this soil type. The water seldom gets very deep, nor does it remain long, and little sediment is deposited. The topography of this soil type is flat, but because of its position adjacent to stream channels it has fair surface drainage. Timber originally covered the land, but most of the areas are now cleared and cultivated.

The surface soil of Yellow-Gray Silt Loam On Clay is 4 to 6 inches thick, yellowish gray in color, and a friable silt loam in texture. The subsurface varies in thickness from 8 to 15 inches, is somewhat grayer in color than the surface, and of a silty clay-loam texture. The upper subsoil, which begins at 12 to 20 inches, is a pale drabbish-gray loam, plastic but not highly compact. The lower subsoil is more yellowish and friable. Rounded concretions of lime are often present in the lower subsoil. Small black rounded pellets are present on the surface.

Management.—Tile placed 6 to 8 rods apart and shallow surface ditches around the field will effectively drain this soil. It is moderately acid and low in organic matter. The application of limestone as needed and the growing and turning down of clover will considerably increase its productive capacity. Phosphate and potassium fertilizers should be given a trial—phosphate just ahead of wheat and potassium in preparing for corn.

Drab Clay Loam (1521)

What are now regarded as two distinct types were mapped as Drab Clay Loam in Edwards county. Together they occupy 7.71 square miles. That part of the total area along Bon Pas creek has been reclassified as Black Clay Loam, and the original name, Drab Clay Loam, is retained for that in the Little Wabash river valley.

Black Clay Loam. This soil type is potentially the richest soil in Edwards county. It was derived from alluvial material which has remained under swampy conditions until artificially drained. Most of the areas are now protected from overflow, altho during high water and continued rainy seasons difficulty is experienced in getting the water off the land.

The surface soil is 8 to 11 inches thick. It is drabbish brown to black in color and of clay-loam texture. The subsurface is drabbish black with some yellow spots. The subsoil begins at 15 to 18 inches and is a plastic, slightly compact clay loam, drabbish brown in color, heavily splotched with yellow. Below 30 inches the subsoil is drabbish yellow and not so plastic as above. Concretions of lime and the remains of snail shells and other fresh water fossil shells are abundant in this type.

Management.—This soil can be effectively drained with tile if an outlet can be established. It will grow clovers without limestone applications. A legume crop should be plowed under every three or four years to maintain a supply of active organic matter. It is questionable whether any commercial fertilizers can be applied with profit, particularly if farm manure is plentiful and can be used on the land at frequent intervals.

Drab Clay Loam. This type is found in the Little Wabash valley. It was derived from alluvial material brought down by the stream. It has been kept under swampy conditions most of the time. The areas are covered with water following each heavy rain and because of the lack of drainage the water remains until it evaporates.

The surface soil is 6 to 8 inches thick and is a grayish-drab silty clay loam. The subsurface is more nearly gray in color and somewhat heavier in texture than the surface. The subsoil is imperfectly developed and variable in its characteristics. At some places it becomes silty and at others it takes the nature of a clay loam. It is always gray in color and is somewhat compact and plastic.

Management.—Drab Clay Loam is a good soil if it can be properly drained. The difficulty of drainage is in securing an outlet. In all probability a proper outlet will never be obtained until the stream channels are dredged. This is particularly true of Big creek. When an outlet is established this soil can be tiled and good drainage afforded. Clover should be grown and turned under at regular intervals in order to furnish nitrogen and active organic matter. The land should be tested for acidity. Altho not strongly acid, it often needs light limestone applications to insure good clover growth. Much of the area of this type is now in timber, and until good drainage can be obtained it probably should remain so.

Brown Silt Loam On Clay (1526.1)

Brown Silt Loam On Clay occupies 3.13 square miles in Edwards county. It is located on land slightly higher than the adjoining areas of Drab Clay Loam. As in the latter type, the areas of Brown Silt Loam On Clay occurring along Bon Pas creek are more productive than those in Little Wabash river valley. This type was derived in the same manner as Drab Clay Loam except that its surface deposit was silty and it has had better natural drainage.

The surface soil of this type is variable in color and thickness, depending upon the nearness to surrounding types. Near areas of Drab Clay Loam it is dark brown, and near Yellow-Gray Silt Loam On Clay it is light brown. The subsurface is a drabbish-brown silty clay loam. The subsoil begins at a depth of 15 to 18 inches and is a yellowish-drab, somewhat compact and plastic clay loam. It becomes more friable below 28 to 30 inches. Concretions of lime are often present in the subsoil.

Management.—Brown Silt Loam On Clay is one of the most productive soils in Edwards county. Underdrainage should be provided by tiling. Fresh organic matter should be added by plowing under clovers or farm manure. The addition of other fertilizers is questionable at this time.

Yellow-Gray Sandy Loam (1564)

Yellow-Gray Sandy Loam is a minor type in Edwards county, occupying only 397 acres. It occurs as undulating ridges in the valleys of the larger streams. The soil material was deposited from moving water during flood times. The material varies from a fine to medium sand with enough silt and clay to keep it from being drouthy. The color is grayish yellow on the surface, changing to yellow with a reddish cast in the subsoil. The subsoil is slightly compact but not plastic.

Management.—Yellow-Gray Sandy Loam is naturally well drained. It is somewhat acid and should have a limestone application. Either clovers should be grown, or else manure applied, to be turned under in order to add nitrogen and organic matter. This type of soil grows satisfactory clover and small grain crops following proper treatment.

Brown Sandy Loam (1560)

Brown Sandy Loam is likewise a minor type in Edwards county, occupying only 320 acres. The largest area is in the vicinity of the town of Browns, where it resembles Brown Silt Loam On Clay except that it usually has more fine sand in the surface. For a description and suggestions of management of this area, the reader is referred to Brown Silt Loam On Clay (see page 31).

The remainder of the total area of Brown Sandy Loam occurs as undulating ridges along Little Wabash river. These areas are similar to those of Yellow-Gray Sandy Loam in every respect except for the darker color of the surface soil, which indicates that the Brown Sandy Loam areas are the more fertile.

Light Brown Sandy Loam (1560.6)

One area of Light Brown Sandy Loam containing 102 acres, and located in the Wabash river valley, was mapped. This type tends toward drouthiness because of a medium-sandy subsoil. Its surface is light brown in color and a sandy loam in texture.

Management.—This soil will produce satisfactory clover and small grain crops, particularly wheat, if limestone is applied and fresh organic matter added. Corn does not produce good yields except in years of plenteous rainfall.

SWAMP AND BOTTOM-LAND SOILS

The swamp and bottom-land group of soils includes the bottom lands along streams, the swamps, and the poorly drained lowlands. The soil types are of alluvial formation and the land is subject to frequent overflow. Drainage is the most important consideration in the management of this land. Little, if anything, can be done by the individual to correct this poor drainage condition, since dredging and the deepening of the channels of existing streams are necessary to secure an outlet. Under present economic conditions the starting of drainage projects on this type of land is a questionable venture.

Deep Gray Silt Loam (1331)

Deep Gray Silt Loam is the predominating bottom-land type in Edwards county. It occupies about 27 square miles. The material forming this type is mainly silt brought down from upstream uplands and from surrounding hills and deposited by slowly moving water during flood times. It remains under high moisture conditions thruout most of the year. The bottoms are flat, poorly drained, and often swampy.

The soil is not of sufficient age to have much development. Its color is gray on the surface, gradually becoming somewhat lighter with depth. Its texture is silty thruout except on some of the slightly higher-lying areas, where a noticeable compaction occurs at depths varying from 18 to 30 inches. This compaction is rarely over 8 inches thick. Slick spots (see page 23) occasionally occur in these areas.

Management.—Drainage is the most important consideration in the management of Deep Gray Silt Loam. The difficulty of obtaining good drainage in these bottom-land areas has already been discussed. The soil is medium acid and will not grow clover without lime. On areas where overflow and drainage have been taken care of, the additions of fresh organic matter give good increases in corn. Corn is the chief crop because this soil usually does not dry out until early summer and seldom overflows again until after the corn is harvested.

Mixed Loam (1354)

Mixed Loam occurs in small bottom lands at the heads of streams. It occupies 7.08 square miles in Edwards county. It is subject to overflow after each heavy rain, and is continually receiving new deposits of material brought down from adjoining upland. Flood water quickly drains off this land down to the larger bottom lands. The soil material varies from a silty to a fine sandy texture. Being a youthful soil it has little or no development. It ranges in color from gray to yellow and its texture is friable thruout.

Management.—Altho this type is subject to frequent overflow, crops such as corn, cowpeas, and soybeans can be grown to maturity between spring and fall rains. The soil is slightly acid, but because of continuous deposition no treatment is suggested. Practically the entire area of this type is farmed in corn.

Yellow-Brown Silt Loam

The 377 acres of Yellow-Brown Silt Loam in Edwards county form the first bottom-land along Wabash river. This land overflows when the river leaves its channel, but an average of about seven crops in ten years has been obtained. The soil is fertile, well drained, and not acid. No treatment is suggested under these conditions. Most of the land is farmed to corn year after year.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification used.

The soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items, such as native vegetation (whether timber or prairie), topography, and geological origin and formation, may assist in the differentiation of types, altho they are not fundamental to it.

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made wherever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation allowable for any given type.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of this report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of three or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel and Brown Silt Loam Over Gravel.

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been as-

signed an index number. The names of the areas together with their general location and their respective index numbers are given in the following list

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* including three areas, the largest being in the south end of the state
200 *Illinoian moraines,* including the moraines of the Illinoian glaciations
300 *Lower Illinoian glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoian glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoian glaciation,* covering about fourteen counties northwest of the middle Illinoian glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoian
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* formed by material derived from the Illinoian or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the remainder of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoian glaciation. These numbers are especially useful in designating very small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports in connection with the maps.

FIG. 5.—EXAMINING THE SOIL PROFILE

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area, The field work is done by parties of two to four men each. The field season extends from early in April to the last of November. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the county farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as the basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil type boundaries, together with the streams, roads, railroads, canals, town sites, and rock and gravel quarries are placed in their proper locations upon the map while the mapper is on the area. With the rapid development in road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. The samples for this purpose are usually taken in three depths; namely 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 12.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of micro-organisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial micro-organisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

At least ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are absorbed from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are

FIG. 6.—ALL ESSENTIAL PLANT-FOOD ELEMENTS MUST BE PRESENT

The jars in which these corn plants are growing contain pure sand to which have been added various combinations of the essential plant-food elements. If a single one of these elements is omitted, the plants cannot develop; they die after the small supply stored in the seed becomes exhausted.

present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

Table 5 shows the requirements of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorous	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn, stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient; but even these plants are dependent upon the soil for the other elements, and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	....
Superphosphate	.....	140–420	.. ..
Potassium chlorid	. ...	....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 5. [2]Young second-year growth ready to plow under as green manure. [3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of plant-food elements actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such elements as calcium and phosphorus, converting them into available forms for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and supplies calcium, thus encouraging the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the unavailable organic nitrogen into available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve minerals contained in the soil, such as potassium and magnesium compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials than 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the ratio of carbon to nitrogen. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing available phos-

phates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant-food elements by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant-food materials are concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter, and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, owing to the presence of

undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added to neutralize the acidity, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

[1]Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4, have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

The Nitrogen Problem

The nitrogen problem is one of foremost importance in American agriculture. There are four reasons for this: nitrogen is becoming increasingly deficient in most soils; its cost when purchased on the open market is often prohibitive; it is removed from the soil in large amounts by crops; and it is readily lost from soils by leaching. A 50-bushel crop of corn requires about 75 pounds of nitrogen for its growth; and the loss of nitrogen from soils by leaching may vary from a few pounds to over one hundred pounds an acre in a year, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about 69 million pounds of atmospheric nitrogen.

FIG. 7.—LEGUMES CAN OBTAIN THEIR NITROGEN FROM THE AIR

The photograph tells the story of how clover benefits the soil. In the pot at the left all the essential plant-food elements, including nitrogen, are supplied. In the middle jar all the elements, with the single exception of nitrogen, are present. At the right nitrogen is likewise withheld but the proper bacteria are supplied which enable the clover to secure nitrogen from the air.

Leguminous plants such as clover are able, with the aid of certain bacteria, to draw upon the inexhaustible supply of air nitrogen, utilizing it in their food requirements. In so doing these leguminous plants, thru the decay of their own tissues, add to the soil nitrogen that has been taken from the air and transformed into food material that can be assimilated by other kinds of crops that follow.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for plant growth. These are the chemical and the biological fixation of the atmospheric nitrogen. Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of atmospheric nitrogen, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

It may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpea hay contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

Different soil types display great variation in phosphorus content. In Illinois soils a range from 320 to 4,900 pounds an acre has been found in the surface 6⅔ inches, depending mainly on the origin of the soil.

The removal of phosphorus by continuous cropping slowly reduces the amount of this element available for crop use unless its addition is provided for by natural means such as overflow, or by agricultural practices such as the addition of phosphatic fertilizers and the use of rotations in which deep-rooting leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different phosphorus-containing materials that are used as fertilizers. The more important of these are rock phosphate, superphosphate, bone meal, and basic slag.

Rock Phosphate.—Rock phosphate is a mineral substance found in vast deposits in certain regions. A good grade of the rock should contain 12 to 15 percent of the phosphorus element. The rock should be ground to a powder fine enough to pass thru a 100-mesh sieve, or even finer.

Superphosphate.—Superphosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate

itself. By further processing, different concentrations are produced. The most common grades of superphosphate now on the market contain respectively 7, 8¾, and 10½ percent of the element phosphorus, and even more highly concentrated products containing as high as 21 percent are to be had. In fertilizer literature the term phosphorus is usually expressed as "phosphoric acid" (P_2O_5) rather than the element phosphorus (P), and the chemical relation between the two is such as to make the above figures correspond to 16, 20, 24, and 48 percent of phosphoric acid respectively. Besides phosphorus, superphosphate also contains sulfur, which is likewise an element of plant food. In general, phosphorus in superphosphate is considered to be more readily available for absorption by plants than that of raw rock phosphate.

Bone Meal.—Prepared from the bones of animals, bone meal appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen. If the material is purchased only for the sake of the phosphorus, the cost of the nitrogen represents a useless expense. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate, containing about 10 to 12 percent of the element prosphorus and about 1 percent of the element nitrogen.

Basic Slag.—Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore tends to influence the soil reaction in the direction of reducing soil acidity.

Comparative Value of Different Forms of Phosphorus.—Obviously the carrier of phosphorus that gives the most economical returns, considered from all standpoints, is the best one to use. Altho this matter has been the subject of much discussion and investigation, the question remains unsettled. The fact probably is that there is no single carrier that will prove the most economical under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

The relative cheapness of raw rock phosphate as compared with the treated material, superphosphate, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in the form of rock than in the form of superphosphate, the ratio being, under present market conditions, roughly speaking 3½ to 1; that is to say, a dollar will purchase about three and a half times as much of the phosphorus element in the form of rock phosphate as in the form of superphosphate, and this is an important consideration if one is interested in building up a phosphorus reserve in the soil.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating the phosphorus from raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is

important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using superphosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, the silt loams and clay loams, are well stocked with potassium, altho it exists mainly in a very slowly soluble form. Many field experiments in various sections of Illinois during the past twenty-five years have shown little or no response to the application of potassium in the production of our common grain and hay crops. On the light-colored soils of southern Illinois, however, where stable manure has not been employed, potassium has been applied with profit, the benefit appearing mainly in the corn crop.

Peat soils are usually low in potassium content. It has frequently been demonstrated in field experiments that the difference between success and failure in raising crops on peat land depends on the use of a potash fertilizer.

Potassium has proved beneficial also on the so-called "alkali" spots occurring on certain soil types that are rather high in organic matter, including peat and very dark-colored sandy, silt, and clay loams. The potassium salts in this case appear to exert a corrective influence over what seems to be an unbalanced plant-food condition caused by an excess of nitrate in the soil.

Potassium fertilizer may be procured in the form of one of the salts, such as chlorid, sulfate, or carbonate of potassium, and any of these materials may be applied, where needed, at the rate of 50 to 150 pounds an acre, according to the method of distribution. For our most common crops about the only basis for choosing among these forms is the matter of price, taking into consideration the potassium content. Kainit is another substance containing potassium, but it is combined with magnesium in the form of a double salt. It is therefore less concentrated than the salts mentioned, and so should be applied in larger quantities. An application of about 200 pounds or more of kainit to the acre is suggested.

The Calcium and Magnesium Problem

When measured by crop removals of plant-food elements, calcium is often more limited in Illinois soils than is potassium, tho magnesium may occasionally be the low element. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

The annual loss of limestone from the soil depends upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to pre-

scribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply under Illinois conditions.

Physical Improvement of Soils

In the management of most soil types, one very important matter, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is

organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, slightly retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

As a general principle, straw and cornstalks should be turned under, and not burned. Corn-borer control, however, may demand unusual measures, even to the burning of the stalks. There also is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps no form of organic matter acts more beneficially in producing good tilth than cornstalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop be corn or oats, it necessarily suffers and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes.

Systems of Crop Rotation

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including, for the reasons discussed above, a liberal use of legumes. No one can say in advance, for every particular case, what crop rotation will prove best, because of variation in farms and farmers and in prices for produce. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the best adapted for building up poor soils.

Following are a few suggested rotations which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First Year —Corn
Second year—Corn
Third year —Wheat or oats (with clover)
Fourth year—Clover
Fifth Year —Wheat (with clover)
Sixth Year —Clover, or clover and grass

In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed; or, in livestock farming, the field may be used three years for timothy and clover pasture and meadow if desired.

The two following rotations are suggested as especially adapted for combating the corn borer:

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Corn (for silage)
Sixth year —Wheat (with sweet clover)

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Wheat (with alfalfa)
Sixth year —Alfalfa

The first system mentioned above may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)
Fifth year —Clover

First year —Corn
Second year —Soybeans
Third year —Corn
Fourth year —Wheat (with legume)
Fifth year —Legume

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be grown four times. Alfalfa may be grown on a sixth field rotating over all fields if moved every six years.

Four-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat or oats (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute barley or rye for the oats or wheat. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover, or it may include alfalfa used as a biennial. The mixing of alfalfa with clover seed for a legume crop is a recommendable practice. In connection with livestock production it may be desirable to mix grass with the clover for pasture or hay. The value of sweet clover, especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to Those Occurring in Edwards County)

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various soil types. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on soil types described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to forty acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with each crop represented every year.

Farming Systems

On most of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system but certain modifications have been introduced in recent years, as explained in the descriptions of the respective fields.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots at the beginning was usually standardized according to a rather definite system. With advancing experience, however, new problems arose calling for new experiments, so that on most of the fields plots have been divided and a portion given over to new systems of treatment, at the same time maintaining the original system essentially unchanged from the beginning.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—Limestone has usually been applied at the rate of 4 tons an acre as an initial application, and 2 tons an acre every four years thereafter until a considerable excess has accumulated in the soil. Rock phosphate has been applied at the rate of one ton an acre at the beginning, followed by an annual acre-rate of 500 pounds applied once in the rotation until a considerable excess has accumulated. Potassium has been applied usually in the form of 200 pounds of kainit a year. When kainit was not available, owing to conditions brought on by the World War, potassium carbonate was used.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated, (sP= superphosphate, bP= bone meal, rP= rock phosphate, slP= slag phosphate)
K = Potassium (usually in the form of kainit)
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed

THE WEST SALEM FIELD

A University soils experiment field is located in Edwards county about a mile west of West Salem. It includes 24 acres of the loessial and drift soils characteristic of the region. A diagram showing the arrangement of the plots is presented in Fig. 8. By means of contour lines, the topography, or slope of the land, is also charted on this diagram. It will be observed that in some parts of the field the land is comparatively level while in other parts it is somewhat rolling and has a tendency to wash.

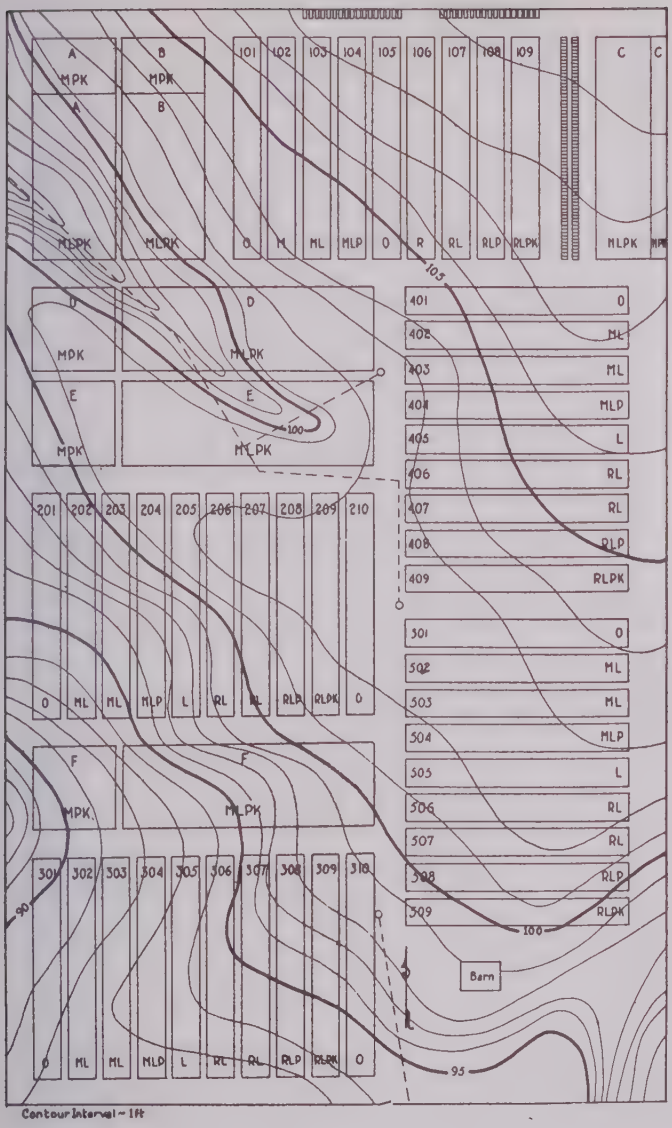


FIG. 8.—DIAGRAM OF THE WEST SALEM SOIL EXPERIMENT FIELD

This diagram shows the arrangement of plots, the soil treatments applied and, by means of contour lines, the natural drainage.

With this variation in the slope of the land it is natural that there would be some corresponding variation in soil type. The predominating types on the field are as follows: Gray Silt Loam On Tight Clay and Yellow-Gray Silt Loam On Tight Clay on the more or less flat-lying portions; Gray Silt Loam On Orange-Mottled Tight Clay and Yellow-Gray Silt Loam On Compact Medium Plastic Clay on the gently rolling areas.

This field has been in operation since 1912 and the experiments as conducted at present may be described under three general headings: the Major Series, the Minor Series, and the Small Plots.

The Major Series

In order to avoid some of the irregularities in the lay of the land, the five groups of plots numbered in the 100, 200, 300, 400, and 500 series and constituting the major series, are distributed over the field in the somewhat irregular fashion shown on the diagram (Fig. 8). Each plot is one-fifth acre in size and there are either 9 or 10 plots in a series. These series are under a crop rotation of corn, soybeans, oats, clover, and wheat. Alsike clover was used until 1920, when sweet clover was substituted, but in 1929 another change was made, the sweet clover being replaced by a timothy-clover mixture.

The soil treatment on these plots follows, in the main, the somewhat standard system described on page 52. An important exception, however, is in the limestone treatment on Plots 2, 5, and 6 which, thru mistake, received the initial application of 4 tons of limestone per acre the same as the regular limestone plots. No more limestone, however, has been added to these plots since this first application in 1912, while the limestone plots proper received their regular periodic applications until 1923.

The rock-phosphate applications were likewise discontinued in 1923, after the phosphate plots had received a total of 4 tons an acre. The practice of returning the wheat straw to the land was dropped in 1924.

Since the results from the West Salem field should be of particular interest in Edwards county, a complete record of all crops grown is included in this Report. The crop yields for every year since the beginning of the experiments on the major series are recorded in Table 7. A summary of these results, showing the average annual yields for the different kinds of crops, including the years since the complete soil treatments have been in effect, will be found in Table 8. The lower part of the table brings out the various direct comparisons between treatments.

In looking over these results one observes first the naturally low plane of productiveness of this land. About 8 bushels of corn, less than 2 bushels of wheat, and absolutely no clover represent the production on an acre of untreated soil, as shown in the results of Plot 1.

On account of the above-mentioned mistake in applying the limestone, these plots afford no test of the effect of organic manures used alone. The effect of manure applied periodically in conjunction with the single application of limestone has proved particularly beneficial to the corn crop, as observed by comparing Plot 2 with Plot 5. A comparison of Plot 6 with Plot 5 shows a beneficial effect produced by crop residues altho less marked than that produced by manure.

Limestone stands out on this land as the prominent agent in soil improvement. Thru the mistake in applying limestone, as explained above, these experiments afford an interesting comparison of two kinds of liming treatment: one in which only an initial application at the rate of 4 tons per acre was made,

TABLE 7.—WEST SALEM FIELD: MAJOR SERIES
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1912 Oats[2]	1913 Soybeans[4]	1914 Wheat[4]	1915 Corn	1916 Soybeans	1917 Oats	1918 Clover	1919 Wheat	1920 Corn	1921 Soybeans	1922 Oats	1923 Sweet clover	1924 Wheat	1925 Corn	1926 Soybeans	1927 Oats[5]	1928 Mixed hay	1929 Wheat
101	0	14.4	(.32)	.1	15.6	(1.21)	5.8	(0)	1.7	4.7	6.0	4.7	0	2.6	4.4	3.5	....	(0)	4.2
102	M(L)[1]	14.4	(.39)	2.5	39.3	(1.86)	32.8	(.71)	10.8	22.1	8.2	13.0	.81	5.9	14.9	8.5	....	(.51)	17.6
103	ML	11.7	(.36)	2.7	36.6	(1.57)	35.8	(.65)	11.8	33.9	8.8	16.9	1.14	9.7	15.1	10.7	....	(1.24)	21.0
104	MLP	12.0	(.39)	7.4	38.9	(1.68)	41.4	(.72)	19.3	35.7	9.8	18.0	.37	18.8	15.8	10.8	....	(2.01)	28.2
105	(L)[1]	11.7	2.8	2.8	22.4	8.6	32.7	.75	7.6	8.4	7.7	9.7	.66	2.9	5.8	5.2	....	(.35)	11.3
106	R(L)[1]	10.2	3.3	2.3	31.5	11.8	35.2	1.00	9.7	14.1	9.2	12.8	.92	5.8	9.2	5.8	....	(.41)	13.6
107	RL	10.9	3.4	3.3	35.8	13.8	35.2	1.00	14.7	11.2	9.7	14.7	.81	14.4	9.3	8.6	....	(1.04)	15.2
108	RLP	11.1	3.7	7.9	43.7	16.9	40.6	1.25	21.8	25.3	10.6	16.3	.26	27.2	10.7	9.7	....	(1.60)	19.1
109	RLPK	11.3	4.8	8.8	49.3	18.9	49.2	1.25	25.4	44.9	13.7	17.0	.55	30.2	16.9	13.2	....	(1.98)	25.8
110	0	10.8	3.7	.2	16.8	(.97)	17.2	(0)	3.6	11.5	6.3	6.3	0	1.4	7.4	5.0	....	(0)	3.2

		Cowpeas[2]	Oats[4]	Soybeans[4]	Wheat[4]	Corn	Soybeans	Oats	Soybeans	Wheat	Corn	Soybeans	Oats	Sweet clover	Wheat	Corn	Soybeans	Stubble Oats hay	Mixed hay
201	0	(1.05)	7.3	(.18)	3.5	25.4	(1.06)	25.0	(.82)	.2	25.5	10.0	16.7	0	20.6	13.2	0	7.8 (0)	(.77)
202	M(L)[1]	(1.05)	7.3	(.20)	6.6	40.8	(1.22)	38.8	(1.08)	3.5	41.1	10.7	26.9	1.18	20.4	23.3	10.3	28.0 (.29)	(1.17)
203	ML	(.85)	6.4	(.19)	6.2	38.1	(1.03)	35.9	(1.08)	3.8	42.0	10.8	28.3	4.83	15.8	19.5	16.0	35.2 (.47)	(1.30)
204	MLP	(.88)	7.0	(.23)	12.6	41.5	(1.21)	42.7	(1.20)	4.8	43.8	12.7	33.9	5.58	30.7	24.7	18.4	32.5 (.58)	(2.02)
205	(L)[1]	(.82)	5.6	.9	5.2	26.3	5.7	35.0	(.76)	1.0	22.1	7.7	14.1	0	11.0	7.8	3.1	5.6 (.01)	(.20)
206	R(L)[1]	[3]	6.1	.8	6.8	33.4	7.5	33.1	5.8	.9	28.9	8.7	20.8	0	13.4	11.3	7.0	8.9 (.07)	(.44)
207	RL	[3]	5.2	.9	8.2	34.7	8.0	40.2	7.2	2.7	33.8	11.6	29.2	3.92	20.2	16.2	10.2	28.3 (.20)	(.93)
208	RLP	[3]	7.3	1.6	15.7	49.6	10.7	46.1	9.6	3.5	39.8	15.3	29.7	5.08	35.4	27.4	16.5	39.5 (.46)	(1.49)
209	RLPK	[3]	8.6	1.2	22.7	48.0	10.6	49.5	9.7	7.8	39.9	15.8	33.0	5.67	39.8	22.7	21.2	42.0 (.64)	(1.91)
210	0	(.94)	6.1	(.09)	1.7	15.3	(.46)	23.0	3.7	0	19.3	6.8	12.7	0	9.6	10.9	0	6.9 (0)	(.52)

		Corn[2]	Soybeans[4]	Oats[4]	Oat hay	Soybeans[4]	Wheat[4]	Corn	Soybeans	Oats	Soybeans	Wheat	Corn	Soybeans	Oats	Sweet clover	Wheat	Corn	Soybeans	Wheat
301	0	14.8	(.67)	1.1	(.11)	(1.40)	0	17.8	(.95)	6.6	(.13)	5.0	24.8	6.4	22.0	1.19	7.4	12.2	(.40)	6.0
302	M(L)[1]	20.2	(.59)	1.2	(.12)	(.90)	.1	29.4	(1.19)	13.0	(.36)	8.5	34.2	8.2	31.6	2.05	14.8	28.4	(1.18)	11.0
303	ML	17.3	(.67)	.9	(.16)	(.90)	.1	34.2	(1.29)	15.6	(.73)	11.7	41.6	11.0	41.1	3.83	28.7	37.2	(1.58)	18.1
304	MLP	12.2	(.64)	1.1	(.19)	(.98)	.3	34.1	(1.41)	17.7	(.56)	14.5	45.0	11.2	42.7	2.78	32.6	51.2	(1.70)	21.2
305	(L)[1]	9.9	4.2	.5	(.21)	6.4	.1	16.7	(.62)	10.6	3.2	7.7	15.6	5.3	12.8	.17	4.7	5.6	(.72)	7.4
306	R(L)[1]	12.8	4.7	.3	....	8.2	.1	25.0	6.6	15.5	3.5	9.6	22.2	7.6	21.4	.75	11.3	8.9	(.85)	8.7
307	RL	12.5	5.8	1.1	....	8.2	.1	29.5	7.1	15.8	6.6	11.0	27.2	8.8	34.8	3.00	19.9	15.7	(1.18)	15.7
308	RLP	8.7	5.2	1.7	....	9.8	.1	29.7	8.8	18.0	6.5	14.8	29.8	10.9	45.3	3.08	28.2	19.4	(1.55)	17.3
309	RLPK	14.7	4.9	1.9	....	13.6	1.2	47.4	11.8	21.4	10.4	18.8	48.6	12.4	45.3	4.50	34.2	40.8	(1.80)	20.1
310	0	12.9	3.9	.5	(.04)	(.99)	0	10.3	3.4	5.6	(.23)	1.6	12.9	4.1	5.6	0	.9	3.0	(.40)	1.3

[1]Parentheses enclosing the letter L indicate one application of limestone only. [2]No treatment. [3]Growth plowed down. [4]No manure. [5]Crop failure.

TABLE 7.—*Concluded*

Bushels or (tons) per acre

Plot No.	Soil treatment applied	1912 Oats[2]	1913 Corn	1914 Soybeans	1915 Oats	1916 Clover	1917 Wheat	1918 Corn	1919 Soybeans	1920 Oats Stubble clover	1921 Sweet clover	1922 Wheat	1923 Corn	1924 Soybeans	1925 Oats	1926 Sweet clover	1927 Stubble Wheat clover	1928 Corn	1929 Oats
401	0	16.4	5.0	(.40)	13.6	(0)	2.2	9.6	(.80)	1.4 (0)	0	2.8	19.5	3.5	3.3	0	2.6 (0)	5.0	32.3
402	M(L)[1]	16.6	6.4	(.50)	19.1	(0)	6.8	15.9	(1.30)	15.0 (.20)	1.08	11.0	52.0	8.9	23.4	.72	14.5 (0)	15.5	43.6
403	ML	19.5	10.8	(.58)	10.5	(0)	10.1	17.2	(1.25)	16.2 (.25)	1.25	15.8	59.7	11.3	33.3	2.17	22.9 (.55)	28.5	60.9
404	MLP	17.0	9.4	(.81)	24.2	(.76)	16.8	18.0	(1.24)	23.1 (.32)	.92	19.3	57.9	11.8	36.7	1.92	27.8 (.62)	32.4	63.1
405	(L)[1]	15.2	5.4	4.5	28.3	.42	11.2	11.4	3.8	6.4 (.16)	.75	9.1	31.2	6.1	12.2	0	10.3 (0)	13.0	35.3
406	R(L)[1]	17.7	10.6	6.7	21.7	.92	12.5	17.8	5.0	13.3 (.36)	.75	12.7	38.3	7.5	18.6	.42	13.2 (0)	23.8	43.0
407	RL	18.0	9.3	7.4	23.0	.83	13.0	21.7	6.4	16.6 (.44)	1.25	13.6	38.7	10.5	29.4	2.17	16.6 (.47)	32.1	54.5
408	RLP	7.0	20.5	10.2	22.3	1.17	21.6	27.4	7.8	19.4 (.61)	1.25	21.7	50.2	12.7	37.5	1.98	28.9 (.73)	30.3	70.5
409	RLPK	12.2	14.2	9.6	30.9	2.17	23.3	28.2	5.6	15.6 (.71)	1.42	20.3	57.9	12.9	46.1	2.04	33.1 (1.05)	35.0	61.6
		Cowpeas[2]	Wheat[4]	Corn	Soybeans	Oats	Soybeans	Wheat	Corn	Soybeans	Oats	Sweet clover	Wheat	Corn	Soybeans	Oats	Sweet clover	Spring wheat	Corn
501	0	(.44)	.9	7.7	(.98)	2.5	(.33)	0	5.0	(.30)	19.5	0	1.9	6.5	(.18)	0	0	.2	7.9
502	M(L)[1]	(.41)	3.8	12.6	(1.70)	19.4	(.77)	4.5	28.0	(.68)	49.2	2.08	12.2	31.2	(.45)	14.7	.92	7.9	36.3
503	ML	(.46)	5.1	8.6	(1.71)	18.6	(.71)	8.1	32.1	(.42)	52.5	3.25	14.4	35.8	(.52)	18.8	1.50	8.2	42.6
504	MLP	(.68)	3.8	8.6	(1.53)	20.6	(.86)	11.0	36.5	(.73)	56.9	2.33	17.9	40.5	(.55)	23.9	.67	11.6	47.6
505	(L)[1]	(.66)	3.8	8.4	10.9	15.8	8.1	7.6	23.1	5.3	36.7	1.58	8.2	19.6	(.38)	5.5	.06	4.6	14.8
506	R(L)[1]	.. [3]	5.7	12.4	13.2	18.6	7.4	7.3	24.8	7.2	37.8	2.00	6.9	28.7	(.40)	10.9	.06	6.2	24.6
507	RL	.. [3]	4.4	11.2	12.0	18.4	6.6	7.2	26.2	8.5	41.7	2.92	7.1	31.9	(.48)	17.5	1.08	7.8	25.3
508	RLP	.. [3]	7.8	13.5	12.6	23.4	8.5	12.5	32.1	8.6	54.1	3.08	11.7	42.7	(.55)	25.5	.59	12.5	27.8
509	RLPK	.. [3]	11.1	17.2	13.2	27.0	8.8	18.2	36.6	11.6	54.1	3.33	19.3	51.1	(.55)	37.0	1.17	16.7	52.2

[1]Parentheses enclosing the letter L indicate one application of limestone only. [2]No treatment. [3]Growth plowed down in 1912. [4]No manure.

TABLE 8.—WEST SALEM FIELD, MAJOR SERIES: SUMMARY OF CROP YIELDS
Average Annual Yields 1913-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *17 crops*	Oats *15 crops*	Wheat *14 crops*	Soybeans *15 crops*	Legume hay[2] *7 crops*	Sweet clover *7 crops*	Stubble clover *2 crops*
1	0	12.4	10.7	4.1	6.1	(.29)	.19	(0)
2	M(L)[1]	27.7	24.6	10.7	10.4	(.66)	1.29	(.10)
3	ML	31.4	28.0	14.3	11.2	(.81)	2.60	(.40)
4	MLP	34.2	31.8	19.6	12.2	(1.15)	2.13	(.47)
5	(L)[1]	15.2	17.4	7.5	6.1	(.52)	.48	(.08)
6	R(L)[1]	21.4	19.7	9.4	7.8	(.63)	.75	(.18)
7	RL	24.1	26.6	12.8	9.3	(.83)	2.23	(.48)
8	RLP	30.6	32.5	19.7	11.5	(1.14)	2.28	(.67)
9	RLPK	38.3	35.4	23.8	12.9	(1.46)	2.78	(.90)
	Crop Increases							
	M(L) over (L)	12.5	7.2	3.2	4.3	(.14)	.81	(.02)
	R(L) over (L)	6.2	2.3	1.9	1.7	(.11)	.27	(.10)
	(L) over 0	2.8	6.7	3.4	0	(.23)	.29	(.08)
	ML over M(L)	3.7	3.4	3.6	.8	(.15)	1.31	(.30)
	RL over R(L)	2.7	6.9	3.4	1.5	(.20)	1.48	(.30)
	MLP over ML	2.8	3.8	5.3	1.0	(.34)	−.47	(.07)
	RLP over RL	6.5	5.9	6.9	2.2	(.31)	.05	(.19)
	RLPK over RLP	7.7	2.9	4.1	1.4	(.32)	.50	(.23)

[1]Parentheses enclosing the letter L indicate one application of limestone only. [2]Including some seed crops evaluated as hay.

and the other in which the regular periodic applications were continued for twelve years, during which time an average of 8½ tons an acre has been applied. These two liming treatments are indicated in the tables by the use of the symbol L for the regular repeated applications and (L) for the single application.

The single treatment of limestone has produced an annual increase of 6.6 bushels of corn an acre, nearly 11 bushels of oats, about 5 bushels of wheat, and about ½ ton of hay, over the untreated land.

Of great practical concern is the lasting effect of limestone, and in this connection some interesting data are furnished by comparing the crops produced year by year from the single treatment with those produced by the continued application. The figures shown in Table 9 furnish such a comparison. The data include the results of both livestock and grain systems of farming reduced to terms of increase in value per acre of crop yields.

During the first nine years after the single 4-ton application there was a constantly increasing response to the treatment, after which time the beneficial effect gradually diminished. Also, during the first few years the continued applications showed little or no advantage over the single treatment, but as the effect of the single treatment began to decline, the advantage of the continued applications came more and more in evidence. Thus it appears that under the conditions of this experiment a single 4-ton application of limestone was fully as effective as the continued liming treatment for a period of at least nine years.

Regarding the response to rock phosphate on this field it may be said that, considering the cost of material, the gains from its use in the manure system have

TABLE 9.—COMPARISON BETWEEN A SINGLE AND REPEATED APPLICATIONS OF LIMESTONE
West Salem Field 1912-1929

YEAR	Value of crop increases for a single application of limestone[1]	Value of crop increases for repeated applications of limestone[1]	
		Livestock system	Grain system
1912	$— .31	$— .52	$— .28
1913	1.14	1.07	1.34
1914	1.23	1.16	1.27
1915	1.43	1.02	1.55
1916	1.85	1.60	2.07
1917	2.66	2.65	2.95
1918	3.39	3.39	3.92
1919	3.86	4.11	4.67
1920	3.89	4.75	4.44
1921	2.76	3.82	4.05
1922	2.76	3.48	4.62
1923	2.82	4.93	4.61
1924	2.60	6.48	6.31
1925	1.72	5.96	6.55
1926	.93	6.06	6.72
1927	.54	5.77	6.44
1928	.49	6.09	7.33
1929	.97	5.33	6.23

[1]Crop values used were as follows: corn, 50 cents; oats, 30 cents; wheat $1.00; soybeans,$1.00 a bushel; and hay $10 a ton.

been scarcely sufficient to pay the expense. In the residues system, however, phosphate used in connection with residues and limestone has given profitable returns.

Used in combination with residues, lime, and phosphate, the potassium compound has produced profitable increases in crop yield, the beneficial effect being greatest on the corn crop.

The Minor Series

Plots A, B, C, D, E, and F, constituting the minor series, differ in shape and size from the regular plots, as indicated on the diagram in Fig. 8. In the earlier years these plots were used for a five-year rotation of potatoes, corn, soybeans, wheat, and sweet clover, with alfalfa on the sixth plot for a period of six years, after which it was shifted. These plots received manure, limestone, rock phosphate, and kainit. In 1921 the rotation was divided into two three-year rotations. On Plots A, B, and C a rotation of wheat and sweet clover on two plots, with a mixture of timothy, alsike, and red clover on the third plot for a period of three years, was used. On Plots D, E, and F a rotation was planned consisting of corn, wheat (with sweet clover) on two plots, while the hay mixture mentioned above was grown on the third plot for three years. Each plot is divided and one part receives manure, phosphate, and potassium while the remainder receives limestone in addition to this combination.

The annual acre-yields are recorded in detail in Table 10 and these results are summarized in Table 11. The results for the limestone treatment confirm those of the major series in showing the beneficial effect of this material.

TABLE 10.—WEST SALEM FIELD: MINOR SERIES
Annual Crop Yields—Bushels or (tons) per acre

Plot	Soil treatment applied	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929
A	MLPK	6.7	18.2	5.9	1.0	(1.25)	28.1	(3.00)	5.2	10.6	1.70	11.4	3.70	29.2	1.67	(1.89)	(2.84)	(1.84)
	MPK	4.3	5.1	1.9	0	(0)	34.4	(1.71)	1.4	7.8	0	5.0	0	13.7	0	(.33)	(0)	(.56)
		Corn[1]	Soy-beans[1]	Wheat[1]	Sweet clover[1]	Pota.	Sor-ghum[3]	Soy-beans	Stubble Wheat clover	Sweet clover	Wheat	Sweet clover	Tim.	Tim., clover	Tim., clover	Stubble Wheat clover	Sweet clover	Wheat
B	MLPK	10.8	1.3	4.3	.85	29.6	.....	(.84)	4.7 (.23)	.78	24.3	.35	(2.57)	(1.14)	(1.21)	19.1 (1.31)	.39	23.5
	MPK	10.5	.8	5.9	.11	15.2	.....	(.35)	.4 (0)	.0	8.9	.30	(.91)	(.31)	(.28)	22.0 (0)	0	6.8
		Soy-beans[1]	Wheat[1]	Sweet clover[1]	Pota.	Corn	Soy-beans	Wheat	Sweet clover	Tim. mix	Tim.	Tim.	Sweet clover	Sweet clover	Wheat	Sweet clover	Spring wheat	Sweet clover
C	MLPK	3.2	9.5	(2.35)	42.7	34.5	(1.03)	22.3	(1.19)	(.82)	(2.58)	(2.64)	(2.23)	6.25	38.0	1.08	18.2	.51
	MPK	2.3	1.0	(1.43)[2]	9.2	11.6	(.38)	7.3	(0)	(.16)	(.99)	(1.14)	(.79)	2.00	16.2	0	5.3	0
		Wheat[1]	Sweet clover[1,3]	Pota.	Corn	Soy-beans	Wheat	Legume hay	Potatoes	Wheat	Corn	Wheat	Corn	Wheat	Corn	Mixed hay	Mixed hay	Mixed hay
D	MLPK	7.8	.....	123.4	42.8	8.5	10.9	(3.66)	15.2	24.8	54.5	8.6	44.9	18.6	25.5	(1.27)	(2.29)	(1.16)
	MPK		.....	45.1	22.8	3.4	7.6	(.29)	14.7	14.9	25.9	4.9	12.4	5.3	12.2	(.26)	(.12)	(.40)
		Oats[1]	Pota.	Corn	Soy-beans	Wheat	Sweet clover	Alfalfa	Alfalfa[3]	Corn	Wheat	Corn	Soy-beans	Tim., clover	Tim., clover	Stubble Wheat clover	Corn	Wheat
E	MLPK	6.6	2.8	63.9	12.9	25.6	(1.20)	(1.01)	.....	42.2	18.8	51.9	(1.25)	(.87)	(1.72)	23.9 (1.63)	36.2	18.7
	MPK	0	.6	38.6	2.1	8.5	(0)	(0)	.....	31.3	11.9	40.7	(.69)	(.34)	(0)	23.2 (0)	16.0	8.2
		Alfalfa	Alfalfa[3]	Alfalfa	Alfalfa[3]	Alfalfa	Alfalfa	Pota.	Soybeans	Tim. mix.	Tim.	Tim.	Sweet clover	Corn	Wheat	Corn	Spring wheat	Corn
F	MLPK	(1.10)	.....	(4.33)	.....	(1.69)	(1.70)	1.9	10.4	(1.44)	(2.47)	(2.51)	(1.47)	21.3	40.2	11.0	10.2	30.4
	MPK	(.24)[2]	.....	(.55)[2]	.....	(.36)[2]	(0)	0	7.1	(.66)	(1.53)	(1.53)	(.50)	15.0	20.4	8.0	3.4	25.4

[1]No manure. [2]Growth mostly weeds. [3]No yields taken.

TABLE 11.—WEST SALEM FIELD, MINOR PLOTS: SUMMARY OF CROP YIELDS
Average Annual Yields 1921-1929—Bushels or (tons) per acre

Soil treatment applied	Plots A, B, C Rotation: wheat, sweet clover, mixed hay				Plots D, E, F Rotation: wheat (with sweet clover), corn, mixed hay				
	Wheat *8 crops*	Sweet clover *9 crops*	Stubble clover *2 crops*	Mixed hay *9 crops*	Wheat *8 crops*	Corn *9 crops*	Soy-beans *1 crop*	Stubble clover *2 crops*	Mixed hay *8 crops*
MLPK	21.7	1.83	(1.77)	(1.95)	20.4	35.3	(1.25)	(1.55)	(1.71)
MPK	10.7	.26	(.40)	(.52)	11.5	20.8	(.69)	(.25)	(.60)
Crop Increases									
MLPK over MPK	11.0	1.57	(1.37)	(1.43)	8.9	14.5	(.56)	(1.30)	(1.11)

The Small Plots

In 1929 certain new lines of work of more intensive nature were started on the West Salem field, for which purpose two sets of small plots were laid out. One set, located on old Plot 110, is given over to a study of the relation between soil reaction and the availability of phosphorus in rock phosphate. The other set of small plots is located along the edge of the north border and is to be devoted to a study of the effect of sodium nitrate applied as a top dressing to wheat. Since this small-plot work has just been initiated, no results have yet been obtained.

THE RALEIGH FIELD

Two series of plots on the Raleigh experiment field located in Saline county are fairly representative of Yellow-Gray Silt Loam On Tight Clay as it occurs in Edwards county. The results of Series 200 and 300 on this field are therefore presented here.

The layout and soil treatments on these series of plots are in accordance with the standard plan described above (page 52). The cropping program has included wheat, corn, oats, and a legume in rotation, the legume being either soybeans, clover, or a clover-timothy mixture. A summary of the results in form of the average annual yields is given in Table 12.

The figures show some increases for the use of manure, but very little benefit from residues alone. Limestone used either with manure or with residues has produced very substantial gains. Rock phosphate in combination with organic manure and limestone has produced in general small increases in all crops, but the gains are by far too small to cover the cost of material.

Potassium applied in the form of kainit has produced a 3-bushel increase in wheat and more than a 7-bushel increase in corn, but the effect on other crops is not significant. These results suggest the possibility of reducing the amount of kainit used to about one-half the present quantity, thereby reducing the expense. It might be that such a modification of the practice would result in profitable returns for the use of potassium on this soil.

FIG. 9.—CORN ON THE RALEIGH FIELD

At the right no treatment has been applied; at the left, manure, limestone, and phosphate have been applied, the major effect being produced by limestone and manure.

FIG. 10.—CORN ON THE RALEIGH FIELD

The treatment here is the same as that shown in Fig. 9 except that no manure is used, the organic matter being supplied by crop residues, including stalks, straw, and legumes plowed under.

TABLE 12.—RALEIGH FIELD, SERIES 200 AND 300: SUMMARY OF CROP YIELDS
Average Annual Yields 1912-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *6 crops*	Corn *10 crops*	Oats *10 crops*	Soybeans *6 crops*	Mixed hay *2 crops*
1	0	2.2	11.4	10.1	(.64)	(.13)
2	M	4.5	23.4	15.6	(.83)	(.06)
3	ML	12.8	40.0	26.3	(1.29)	(.60)
4	MLP	14.6	41.9	25.9	(1.42)	(.68)
5	0	2.6	12.2	10.6	(.46)	(0)
	R	3.9	16.4	13.5	(.51)	(0)
7	RL	10.0	34.8	23.9	(1.00)	(.18)
8	RLP	11.5	39.9	26.4	(1.12)	(.32)
9	RLPK	14.5	47.3	27.3	(1.21)	(.60)
10	0	4.5	19.7	14.0	(.83)	(.06)
	Crop Increases					
	M over 0	2.3	12.0	5.5	(.19)	—(.07)
	R over 0	1.3	4.2	2.9	(.05)	(0)
	ML over M	8.3	16.6	10.7	(.46)	(.54)
	RL over R	6.1	18.4	10.4	(.49)	(.18)
	MLP over ML	1.8	1.9	— .4	(.13)	(.08)
	RLP over RL	1.5	5.1	2.5	(.12)	(.14)
	RLPK over RLP	3.0	7.4	.9	(.09)	(.28)

THE SPARTA FIELD

Field experiments on soil representative of the type Light Gray Silt Loam On Tight Clay have been conducted on the Sparta field. This field, which was established in 1916, is located in Randolph county at the north edge of the town of Sparta. For the present purpose the discussion will be confined to the plots of Series 200, 300, and 400.

These plots are under a crop rotation of corn, soybeans, wheat, and clover, chiefly sweet clover. Formerly cowpeas were sown in the corn as a cover crop on the residues plots, but this practice has been abandoned as unprofitable. The soil treatments are as indicated in the accompanying table, and they have been applied in the manner previously described, page 52, with the exception that the initial application of limestone was at the rate of 5 tons an acre instead of 4 tons. A summary of the average annual yields of the respective crops, including the years since the complete plot treatments have been in effect, are given in Table 13.

The low yields on the untreated plots testify to the natural poverty of this soil, altho this particular piece of land, on account of its favorable location with respect to drainage, is regarded as rather more productive than the general run of the type that it represents. Neither manure alone nor residues alone has much effect in improving crop yields. A sharp increase, however, follows the application of limestone used either with manure or with residues. Without limestone, clover refuses to grow; with limestone, fair crops of clover have been obtained.

TABLE 13.—SPARTA FIELD, SERIES 200, 300, 400: SUMMARY OF CROP YIELDS
Average Annual Yields 1917-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *10 crops*	Soybeans *10 crops*	Wheat *8 crops*	Oats *1 crop*	Clover *1 crop*
1	0	17.3	5.9	3.7	24.4	(0)
2	M	22.4	7.7	6.6	21.9	(0)
3	ML	32.7	14.6	15.9	39.1	(2.06)
4	MLP	34.9	14.8	16.7	40.0	(1.75)
5	0	13.0	3.9	4.9	8.1	(0)
6	R	18.6	5.1	5.0	16.9	(0)
7	RL	26.5	12.8	15.1	34.4	(1.59)
8	RLP	26.1	13.3	16.2	32.5	(1.72)
9	RLPK	33.4	14.2	16.6	34.7	(2.74)
10	0	11.6	3.7	3.9	15.0	(0)
	Crop Increases					
	M over 0	5.1	1.8	2.9	−2.5	(0)
	R over 0	5.6	1.2	.1	8.8	(0)
	ML over M	10.3	6.9	9.3	17.2	(2.06)
	RL over L	7.9	7.7	10.1	17.5	(1.59)
	MLP over ML	2.2	.2	.8	.9	−(.31)
	RLP over RL	− .4	.5	1.1	−1.9	(.13)
	RLPK over RLP	7.3	.9	.4	2.2	(1.02)

Rock phosphate has produced no significant effect whether used with manure or with residues. Potassium seems to have been of some benefit to the corn and clover. It is possible that the application of smaller quantities of potassium directly to these crops would prove a more economical way to use potassium fertilizer on this soil.

On the whole the experimental results on the Sparta field are similar to those of the Raleigh field in showing a very positive need for limestone and organic matter, with the possibility of a profitable response from potassium fertilizer if used in moderate quantity.

It should be observed that altho a very decided response to proper soil treatment is manifested, amounting to several hundred percent increase in yield, yet under the best treatment the general plane of production is relatively low. These experimental results are valuable in indicating principles, but it is easy to perceive that if farming on this land is to be made profitable, other systems of management than the cropping system of these experiments must be employed. Such systems would include the raising of some livestock and perhaps the introduction of certain crop specialties.

THE ENFIELD FIELD

As representing the soil type Yellow-Gray Silt Loam On Medium Plastic Clay, results from experiments of certain plots on the Enfield field are introduced. This field is located in White county about a mile east of Enfield and has been in operation since 1912. The somewhat standard cropping system and

TABLE 14.—ENFIELD FIELD, SERIES 100: SUMMARY OF CROP YIELDS
Average Annual Yields 1915-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *3 crops*	Corn *4 crops*	Oats *4 crops*	Soybeans *1 crop*	Sweet clover *1 crop*	Mixed hay *2 crops*
1	0	5.4	13.8	11.8	(.99)	(0)	(.07)
2	M	8.6	25.6	18.2	(1.14)	(0)	(.45)
3	ML	16.7	33.9	33.6	(1.62)	(.75)	(2.01)
4	MLP	20.7	36.1	34.7	(1.96)	(.75)	(2.23)
5	0	8.3	14.6	10.8	(.50)	(0)	(.27)
6	R	8.6	18.6	10.7	(.50)	(0)	(.22)
7	RL	19.9	28.5	28.7	(1.35)	(.50)	(1.55)
8	RLP	23.5	30.7	32.5	(1.56)	(.58)	(1.75)
9	RLPK	25.9	39.0	39.0	(1.50)	(.67)	(2.23)
10	0	10.8	20.8	12.0	(1.22)	(0)	(.30)
	Crop Increases						
	M over 0	3.2	11.8	6.4	(.15)	(0)	(.38)
	R over 0	.3	4.0	− .1	(0)	(0)	−(.05)
	ML over M	8.1	8.3	15.4	(.48)	(.75)	(1.56)
	RL over R	11.3	9.9	18.0	(.85)	(.50)	(1.33)
	MLP over ML	4.0	2.2	1.1	(.34)	(0)	(.22)
	RLP over RL	3.6	2.2	3.8	(.21)	(.08)	(.20)
	RLPK over RLP	2.4	8.3	6.5	−(.06)	(.09)	(.48)

soil-treatment methods described on page 52 were established on Series 100, 200, 300, and 400. On account of some variation in soil type, however, only Series 100 will be considered for the present purpose.

The crops grown have been wheat, corn, oats, soybeans, sweet clover, and mixed hay. The annual average yields for the various soil treatments are set forth in Table 14.

According to these data there is considerable response to stable manure even where used alone. There is, however, very little response to residues where used without supplementary treatment. Limestone is highly effective used either with manure or with residues.

Rock phosphate has produced some increases in nearly all crops in both manure and residues systems, but these gains are scarcely sufficient in either system to render the use of this material remunerative. Kainit has made a fairly good record, particularly in the corn and hay yields. In fact these results seem to justify the recommendation of a trial of some form of potassium fertilizer used in moderate quantity along with limestone and organic manure on this soil type.

THE ELIZABETHTOWN FIELD

A description of the soil of the Elizabethtown field corresponds closely to that of the Reddish Yellow-Gray Silt Loam and the Reddish Yellow Silt Loam found on much of the rolling and hilly land in Edwards county. The results of experiments on this field, therefore, should be of interest in connection with the management of these and closely related soil types.

TABLE 15.—ELIZABETHTOWN FIELD, MAJOR SERIES: SUMMARY OF CROP YIELDS
Average Annual Yields 1919-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *16 crops*	Corn *11 crops*	Soybeans *4 crops*	Sweet clover *3 crops*	Mixed hay *6 crops*
1	0[1]	6.5	19.0	4.7	0	(.18)
2	M	6.5	18.2	4.1	0	(.33)
3	ML	12.3	34.2	6.2	2.01	(1.30)
4	MLP	16.1	40.2	7.8	3.02	(1.81)
5	0[1]	3.9	11.6	2.7	0	(.17)
6	R	4.1	15.4	2.9	0	(.26)
7	RL	9.5	33.3	5.3	2.32	(1.10)
8	RLP	15.1	44.0	7.2	2.67	(1.70)
9	RLPK	16.5	43.6	6.9	2.62	(2.12)
10	0[1]	6.8	21.8	4.4	0	(.14)
	Crop Increases					
	M over 0[1]	2.6	6.6	1.4	0	(.16)
	R over 0[1]	.2	3.8	.2	0	(.09)
	ML over M	5.8	16.0	2.1	2.01	(.97)
	RL over R	5.4	17.9	2.4	2.32	(.84)
	MLP over ML	3.8	6.0	1.6	1.01	(.51)
	RLP over RL	5.6	10.7	1.9	.35	(.60)
	RLPK over RLP	1.4	— .4	— .3	— .05	(.42)

[1]Plot 5 is used in this case as the only check plot.

The Elizabethtown field is located in the southern part of Hardin county on very hilly land. A topographic map shows a range in elevation of 42 feet on that part of the field occupied by the present plots. Erosion is therefore a serious problem. The main experimental work is conducted on four series of plots arranged and treated in the standard fashion described on page 52. The crop rotation first adopted consisted of corn, soybeans, wheat, and sweet clover; but this was changed in 1923 to corn, wheat, timothy-clover mixture, and wheat, with a sweet-clover seeding on the residues plots.

The difficulty of obtaining satisfactory data on land of such rough topography, where washing from one plot to another is an inherent feature of the experiments, is obvious. Nevertheless there are certain effects of soil treatment standing out in such bold relief as to leave no doubt as to their significance. These effects are brought out by the data presented in Table 15, which gives a summary of the annual yields of the various crops under the respective systems of soil treatment.

The results show extremely poor yields on the untreated land, with very little improvement from the use of manure alone and still less from residues alone. A sharp increase in yield, however, follows the application of limestone, particularly where used with manure.

Thru the introduction of rock phosphate into the soil treatment system, still further gains have been produced. These gains in the manure system have been just about sufficient to cover well the cost of material, but in the residues system a very good profit has been realized from the phosphate.

The addition of potassium in the form of kainit to the combination residues, limestone, and phosphate treatment has had no significant effect on crop yields and is therefore applied at a financial loss.

An economic study of the crop-rotation period ending in 1928, in which account is taken of cost of treatment and value of crops, reveals the fact that of the eight different systems of soil treatment under comparison the residues, limestone, rock phosphate combination was the most profitable.

It is not to be inferred, however, that the general plan of farm management represented in these experiments is the best that might be applied on this land. The data show that soybeans do not thrive well on this field; they might well be replaced, therefore, by some better adapted crop. It seems possible that by modifying this cropping program and giving place to some livestock production in the system, a more profitable farming enterprise could be set up than that represented in the simple rotation employed for these experiments.

THE UNIONVILLE FIELD

The Unionville experiment field, whose soil closely resembles the type Reddish Yellow-Gray Silt Loam as found in Edwards county, is located in the extreme southern part of Illinois in Massac county immediately north of Unionville. The land is undulating in topography. The field is thoroly tile-drained.

Only one of the two general systems of plots occupying this field will be considered for the present purpose. This set of plots is made up of four series

TABLE 16.—UNIONVILLE FIELD, SERIES 100, 200, 300, 400: SUMMARY OF CROP YIELDS
Average Annual Yields 1911-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *13 crops*	Soybeans[1] *17 crops*	Wheat *13 crops*	Cotton[2] *13 crops*	Oats *3 crops*
1	0	15.6	(.76)	5.3	171	16.3
2	M	20.8	(.90)	7.4	284	14.0
3	ML	29.4	(1.30)	13.3	464	32.9
4	MLP	29.7	(1.45)	16.5	479	32.9
5	0	13.8	(.58)	5.6	144	12.8
6	R	16.9	(.62)	6.5	130	20.0
7	RL	32.8	(.86)	14.4	233	35.1
8	RLP	36.4	(.94)	18.2	250	40.8
9	RLPK	41.4	(1.16)	20.4	442	41.0
10	0	14.2	(.67)	6.6	152	11.0
	Crop Increases					
	M over 0	5.2	(.14)	2.1	113	− 2.3
	R over 0	3.1	(.04)	.9	− 14	7.2
	ML over M	8.6	(.40)	5.9	180	18.9
	RL over R	15.9	(.24)	7.9	103	15.1
	MLP over ML	.3	(.15)	3.2	15	0
	RLP over RL	3.6	(.08)	3.8	17	5.7
	RLPK over RLP	5.0	(.22)	2.2	192	.2

[1]Including some crops of cowpea hay. [2]Yields in pounds per acre.

of ten plots each. The cropping program adopted in 1912 included corn, cowpeas, wheat, and cotton, but this rotation was changed in 1922 to corn, rye, cowpeas, and wheat, with a sweet-clover seeding on the residues plots. Two years later cotton was restored to the system, replacing rye in the rotation.

In looking over the results of the various soil treatments on this field, (Table 16), one notes the poor yields on the untreated land. Little effect has been produced by manure alone and still less by residues alone. The improvement in yields made by adding limestone is very evident.

Rock phosphate has produced moderate increases in yields, altho these increases are not sufficient to cover the cost of the material under present market conditions. Potassium likewise gives some increases in yields, particularly in corn and cotton, but as applied in the manner of these experiments it scarcely represents a profitable investment.

The above conclusions are based upon all the results obtained over the entire period since full treatment has been in effect on the respective plots. From a financial study of the rotation period ending in 1928 it appears that in the residues system the combination residues, limestone, phosphate, and kainit has proved the most effective soil treatment of those under trial, thus indicating an increasing response to phosphorus and potassium in later years—an effect that is not surprising.

THE VIENNA FIELD

Edwards county, as indicated in the descriptions of several of its soil types, includes much land that is subject to destruction thru erosion or washing. The experiments conducted on the Vienna field, in Johnson county, to test out differ-

TABLE 17.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

Section A included the steepest part of the field and contained many gullies. The land was built up into terraces at vertical intervals of 5 feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

Section B was used to test the so-called embankment method. Ridges were plowed up which were sufficiently high so that when there were heavy falls of rain the water would break over and run in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about 8 loads of manure an acre were turned under each year for the corn crop.

Section D was washed to about the same extent as Section C. It was farmed in the most convenient way, without any special effort to prevent washing.

FIG. 11.—PROPER SOIL AND CROPPING METHODS WOULD HAVE PREVENTED THIS CONDITION
This abandoned hillside is just over the fence from the field shown in Fig. 12.

ent methods of reclaiming badly gullied land and preventing further erosion will therefore be of considerable interest.

The Vienna field is representative of the sloping, erodible land so common in the extreme southern part of the state. When the experiments were started the whole field, with the exception of about three acres, had been abandoned because so much of the surface soil had washed away, and there were so many gullies that further cultivation was unprofitable. For the purpose of the experiments the field was divided into different sections (see Table 17). These were not entirely uniform; some parts were much more washed than others, and portions of the lower-lying land had been affected by soil material washed

FIG. 12.—CORN GROWING ON AN IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD
This land had formerly been badly eroded. It was reclaimed by proper soil treatment and cropping. Compare with Fig. 11.

down from above. The higher land had a very low producing capacity; on many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except the one designated as D, which included but three plots.

Careful records were kept for nine years. The results, summarized in Table 17, indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels on the check series (D). Wheat yielded 11.1 bushels on the protected series, in comparison with 4.6 bushels on the check, and clover yielded $\frac{4}{5}$ of a ton on the protected series and but $\frac{1}{5}$ of a ton on the check.

Figs. 11 and 12 serve further to indicate what may be done with this type of soil even after it has become badly washed and gullied.

Altho these results show in principle the possibility of improving this land, it cannot be said that the experiments as conducted represent directly the most economical system of farming. However, it appears possible that by modifying the cropping plan in some manner, as for example, substituting sweet clover for cowpeas and giving large place in the farming system to hay and pasture crops, production might be substantially increased and thus a system of farming instituted that would represent a profitable enterprise.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Masón, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1925
33 Saline, 1926
34 Marion, 1926
35 Will, 1926
36 Woodford, 1927
37 Lee, 1927
38 Ogle, 1927
39 Logan, 1927
40 Whiteside, 1928
41 Henry, 1928
42 Morgan, 1928
43 Douglas, 1929
44 Coles, 1929
45 Macon, 1929
46 Edwards, 1930

UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 47

PIATT COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, AND L. H. SMITH

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URBANA, ILLINOIS, DECEMBER, 1930

The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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INTRODUCTORY NOTE

IT IS A MATTER of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or landowner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil management in order to help the farmer and landowner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for it represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due Mr. O. I. Ellis, who, as leader of the field party, was in direct charge of the mapping.

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PIATT COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

GEOGRAPHICAL FEATURES OF PIATT COUNTY

PIATT COUNTY is located near the center of Illinois about 25 miles north of the Shelbyville moraine, which, in this region, marks the dividing line between the dark-colored corn-belt soils to the north and the light-colored soils to the south. The county is about 34 miles north and south by about 15 miles east and west and occupies 432.72 square miles.

Climate

The climate of Piatt county is typical of that prevailing in the Mississippi valley region. It is characterized by a wide range in temperature between the extremes of winter and summer and by an abundant, well-distributed rainfall. The greatest range in temperature for any one year for the twenty-six year period 1903 to 1928, as recorded at Urbana, was 122 degrees in 1905 and again in 1918. The highest temperature was 103° in 1913; the lowest, 25° below zero in 1905. In 1921 the lowest winter temperature was 6° above zero. The summer temperature exceeded 100° during five years and the winter temperature fell below 10° below zero during fourteen years out of the twenty-six year period. The average date of the last killing frost in the spring is April 25; the earliest in the autumn is October 16. The average length of the growing season is 174 days, which is ample time to mature all the crops common to the region. Occasional early frosts result in soft corn when the preceding spring has been very wet and backward. Winter wheat is sometimes injured by sleet and ice, particularly on flat land.

The average annual rainfall for the twenty-six year period was 35.26 inches. The wettest year on record, 1927, had a rainfall of 55.64 inches; the driest year, 1914, had a rainfall of 24.68 inches.

Fig. 1 gives the average monthly rainfall for the twenty-six year period. An average monthly rainfall of more than 3 inches during the growing season would indicate that Piatt county soils receive enough water to maintain a proper moisture supply for the growing crops so that drouths would not occur. It should be borne in mind, however, that the total amount of precipitation is only one of the factors that control drouth; other important factors are humidity, rate of evaporation, rate at which rain falls, lapse of time between rains, and drainage conditions. However, the rainfall in this county is sufficiently well distributed that seldom is there a severe drouth. Occasionally twenty to thirty days pass without much rain so that crop yields are reduced and meadows and pastures are short, but the subsoil rarely becomes so dry that plant roots cannot procure some moisture.

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[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

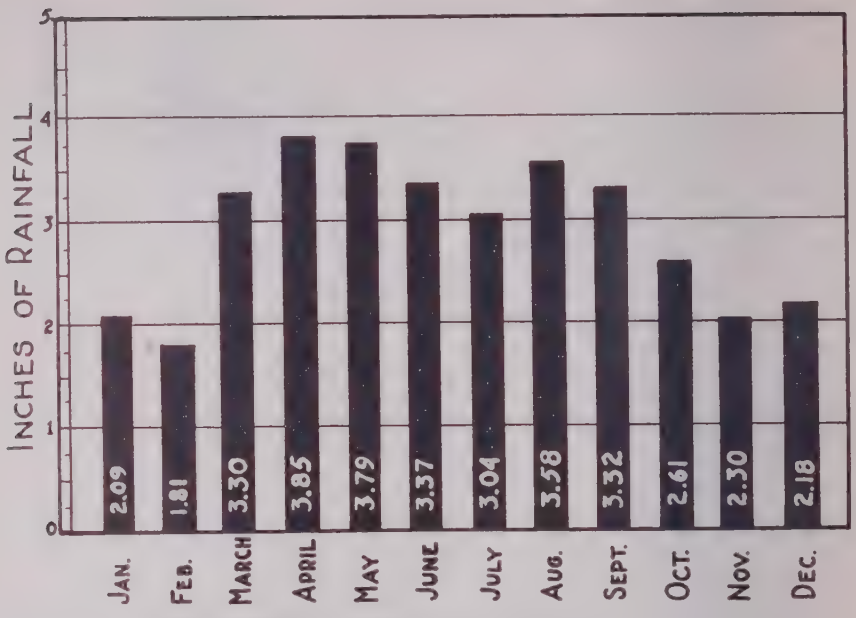

FIG. 1.—AVERAGE MONTHLY DISTRIBUTION OF RAINFALL IN PIATT COUNTY

Physiography and Drainage

Piatt county contains much nearly level land. The northeast corner is gently rolling where the Blue Ridge moraine, a part of the Champaign morainic system, cuts across the northeast corner of the county. Sangamon river traverses the central part of the county in a northeast-southwest direction and is bordered on either side by a narrow belt of gently rolling land. The Cerro Gordo moraine crosses the county parallel to, and on the south side of, Sangamon river. Both of these morainal areas are gently rolling and contain but few slopes sufficiently steep to erode badly if well managed. The remainder of the county contains much land that is so nearly level as to have poor natural drainage.

The southern part of the county, south of the Cerro Gordo moraine, drains into streams of the Kaskaskia river system, while the portion of the county north of this ridge drains into Sangamon river, either directly or thru its tributaries. Dredge ditches have been constructed in the flatter portions of the county to serve as outlets for tiling systems and to carry the large volume of run-off. No soil is known to occur in Piatt county which will not underdrain satisfactorily. The heavy, low-lying areas underdrain more slowly than the more open soils, but their high potential productivity fully justifies the expense of placing the lines of tile close enough together to provide adequate underdrainage. The accompanying drainage map shows the natural drainage of the county and the morainal ridges.

The elevation of Piatt county ranges between 668 and 793 feet. The highest point is in the northeast corner of the county and the lowest in the southeast.

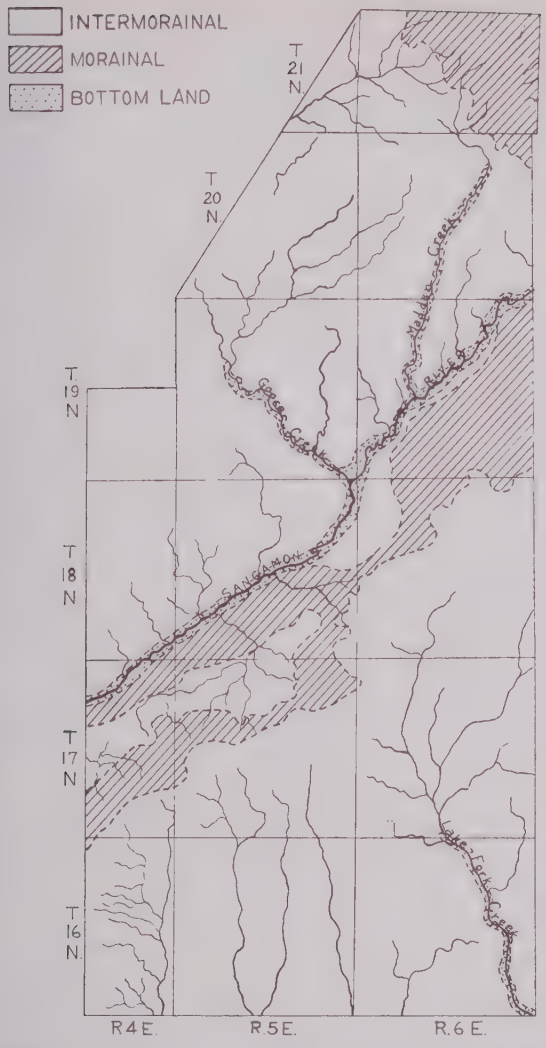

FIG. 2.—DRAINAGE MAP OF PIATT COUNTY SHOWING STREAM COURSES, BOTTOM LANDS, AND MORAINAL AND INTER-MORAINAL AREAS

Settlement and Development

The first settlers in Piatt county were from the Southern states, many of them coming by way of Ohio or Indiana. Having come from forested states, it was years before they learned that the prairies could be cultivated. The poor drainage of much of the prairie land was, no doubt, an important factor in retarding their cultivation. Much artificial drainage had been provided by 1883 and with the extension of the drainage systems the rich, black prairie soils were rapidly brought under the plow.

Monticello was laid out and named in 1837. In 1841 Piatt county was formed from parts of Macon and DeWitt counties, and Monticello was chosen as the county seat.

The Wabash railroad was constructed thru the county in 1855 and 1856, and the railroad between Monticello and Champaign was put into operation in 1870 and extended to Decatur two years later.

Piatt county is now well provided with rail transportation. No farm in the county is over seven miles from a shipping point. State concrete highways traverse the county, as shown on the soil map. The dirt roads are in general well kept, many of them being oiled.

Agricultural Production

The early agriculture in Piatt county was confined largely to small fields cleared in the timber along Sangamon river. Attempts to produce small grains on the prairie were not at first successful because of the rank growth resulting in lodging of the oats and rusting of the wheat. As drainage was provided and the excess of nitrogen and organic matter in the soil was reduced, these difficulties became less acute.

The principal crops grown in Piatt county in the present day are those common to the corn belt. The following figures (taken from Circular 385, Illinois Crop and Livestock Statistics, Illinois Department of Agriculture and U. S. Department of Agriculture cooperating) give the acreage, production, and yield per acre of the more important crops for 1928.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	111,800	4,695,600 bu.	42.0 bu.
Winter wheat	3,800	45,600 bu.	12.0 bu.
Spring wheat	7,600	76,000 bu.	10.0 bu.
Barley	7,630	160,230 bu.	21.0 bu.
Rye	90	1,170 bu.	13.0 bu.
Oats	61,900	2,290,300 bu.	37.0 bu.
White potatoes	250	21,250 bu.	85.0 bu.
Sweet potatoes	15	1,690 bu.	112.6 bu.
Soybeans (alone)	12,000	.....	.....
Soybeans (with other crops)	3,000	.....	.....
Alfalfa (cut for hay)	800	.....	.....
Sweet clover	17,000	.....	.....
Tame hay	10,400	14,560 tons	1.4 tons
Wild hay	35	39 tons	1.1 tons

The above figures are for but a single year, that of 1928. Yields will fluctuate from year to year and for this reason the average yield over a period of years more accurately represents conditions. The U. S. Department of Agriculture gives the following average yields for the eighteen-year period 1911 to 1928: corn, 38 bushels; wheat, 19 bushels; oats, 34 bushels; hay, 1.2 tons. Thus it appears upon comparing the figures for the single year 1928 with these long-time averages that 1928 was a rather favorable year for corn and oats but an exceptionally poor one for wheat.

An important crop of rather recent introduction is the soybean. The great interest in soybeans in this section of the country is shown by the fact that in 1928 there were 12,000 acres in Piatt county devoted to soybeans alone, and on 3,000 other acres soybeans were grown with other crops. The great value of sweet clover as a soil-building and pasture crop is becoming more and more appreciated, as attested by the 17,000 acres devoted to this crop.

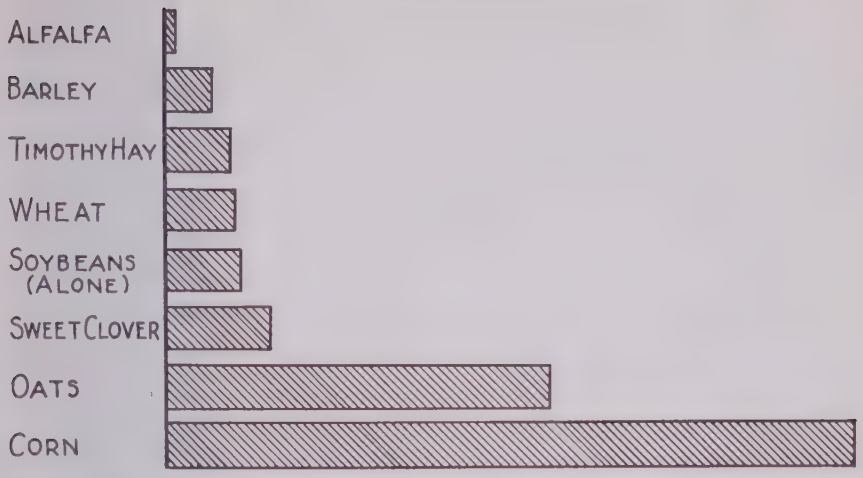

FIG. 3.—RELATIVE ACREAGE OF DIFFERENT KINDS OF FIELD CROPS IN PIATT COUNTY, 1928

It is of interest to note the prominent place being taken by two crops of rather recent introduction, the soybean and sweet clover. (Based on Circ. 385, Ill. Crop and Livestock Statistics, Ill. Dept. Agr. and U.S.D.A. cooperating.)

Fruit and vegetable crops are of little commercial importance in Piatt county. Stock raising was important from an early date. The character of the livestock interests in the county in 1928 is shown by the following figures taken from Circular 385, Illinois Crop and Livestock Statistics, mentioned above:

Animals and Animal Products	*Number*	*Value*
Horses	8,630	$733,500
Mules	1,330	118,300
Cattle (total)	13,170	723,100
Dairy cows	5,660	418,200
Hogs	45,830	641,600
Sheep	3,070	32,300

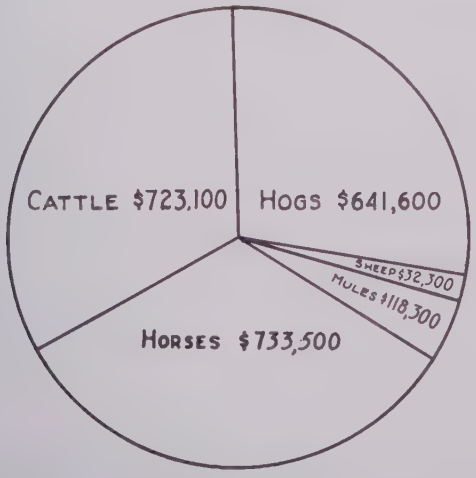

FIG. 4.—RELATIVE VALUE OF THE MORE IMPORTANT CLASSES OF FARM ANIMALS IN PIATT COUNTY

FORMATION OF PIATT COUNTY SOILS

Sources of Soil Materials

Piatt county is covered by a thick deposit of glacial till. The surface of the county prior to glacial times was broken, but the preglacial topography had no influence on present surface conditions, for the deposit of till exceeds 200 feet in thickness over most of the county. The ice sheets, as they passed over the region, rubbed down the hills and filled the valleys, and upon their retreat left a nearly level till plain broken only by the Blue Ridge moraine in the northeast corner of the county and the Cerro Gordo moraine extending in a southwest-northeast direction thru the central part of the county.

The first glacier known to have advanced across the area now occupied by Piatt county is called the Illinoian. This glacier was an immense ice sheet which came from the north and covered most of Illinois. Following the retreat of this glacier there was a long period during which soil was formed on the till left by the Illinoian ice and also on loess deposited at a later time on the Illinoian till. Following this long interglacial stage, another immense ice sheet known as the Wisconsin advanced across the area. The present soils of Piatt county were formed in large part from the till left by the Wisconsin glacier. In a few areas a thin blanket of loess appears to have been deposited on the till, and where such is the case the soils were developed from the loess and are pebble-free.

Over much of the county there seems to have been a local reworking of the soil material by the wind, producing a loess-like cover. Because of the thickness of this deposit the soils developed from it have been classified with the loess soils rather than with the drift soils, tho strictly speaking they are not loess soils.

Flowing water reworked the glacial till and the loess in places, leaving deposits in the form of bottoms, terraces, and outwash plains from which the soils of these areas developed. All of these materials were high in carbonates at the time they were deposited and this fact has an important bearing on the character of the soils developed from them. The till was made up of a great variety of rocks, including limestone. These rocks were ground into various sized particles, including the very finest as well as gravel and stones, and these particles were mixed together, giving a material well supplied with all the elements of plant food. Loess is the "rock flour" produced by the grinding action of the ice sheet. This flour-like material was carried into the bottomlands by glacial streams flowing from the front of the glacier and was then picked up by the wind and deposited over the upland. It is an excellent soil-forming material, rich in the elements of plant food and of such texture that soils developed from it are easy to work. The water-deposited material was laid down in large amounts as outwash plains, terraces, and bottom lands during the retreat of the Wisconsin ice sheet. The transposition of soil material thru washing from the higher- to the lower-lying land has been in progress ever since the retreat of the glacier, and this process is still going on. The rate of this washing was relatively slow prior to the bringing of the land

under cultivation, because of the protection afforded by the timber or by the dense prairie grass. Since the land has been brought under the plow, washing on the more pronounced slopes has been so rapid as to be harmful. Its effect is evidenced by the yellowish color of the surface soil on the slopes which are washing rapidly, and is reflected in the lower crop yields on these areas. Part of the material washed from the higher land is deposited locally on the lower areas resulting in the formation of very youthful soils with little development of the horizons or strata which characterize mature soils.

Process of Soil Development

The various kinds of soil material, whether deposited directly from the glacier, reworked by the wind, or transported by water, all began immediately to undergo change thru the action of weathering forces. The simpler forms of vegetation grew first, these being followed by the higher plants as conditions for their growth became favorable. In the region now included in Piatt county all the conditions were favorable for the accumulation of organic matter over a large proportion of the land. A grass vegetation developed and occupied most of the area, and this condition, together with the high lime and high moisture contents of the soil, favored the accumulation of organic matter and the development of dark-colored soils. A relatively small total area along Sangamon river and in the southeastern corner of the county was occupied by a timber vegetation, which resulted in the development of light-colored soils.

As time went on and weathering continued, the soils as we now know them began to take form. Layers or horizons, often spoken of as surface, subsurface, and subsoil, became distinguishable. The soils of the county are still youthful in the sense that the various parts of the profile are not yet fully developed. In some of the low-lying areas fresh-water shells are still abundant, indicating the short length of time which has elapsed since these areas were swampy. The construction of dredge ditches and the installation of tile have changed the low-lying, swampy areas into highly productive farm land. As time goes on and leaching progresses, the youthful soils in this county will take on the features of maturity and will inevitably become less productive. This change, however, from youth to maturity is extremely slow. So far as the present generation and many generations in the future are concerned, the soils of Piatt county will remain productive unless depleted thru poor soil management methods.

About 94 percent of the soils in Piatt county are dark-colored. These soils were originally high in organic matter and are still well supplied with this important constituent except where no provision has been made in the farming plan for its replenishment and on slopes which have eroded rapidly. The dark-colored soils owe their dark color and high organic-matter content to the prairie grasses which grew there prior to occupation by the white man. The fibrous roots of the grasses were preserved from rapid decay by the swampy conditions in the low lands and by the covering of fine soil and mat of grass stems and leaves on the higher land which partially excluded the oxygen. The mat of grass stems and leaves was at times partially destroyed

by prairie fires and by decay, but it was constantly being renewed and by its protecting action contributed to the accumulation of organic matter in the soil.

Light-colored soils occupy about 6 percent of the total area of the county. These soils are light-colored because they were occupied by a timber vegetation. The conditions in a forest are not favorable for the accumulation of organic matter in the soil. The tree roots are large, and when the tree dies they decay rapidly and completely. The leaves and other debris falling on the surface are exposed to rapid decay and to destruction by timber fires and therefore contribute but little to the organic-matter supply of the soil.

When virgin soil is first plowed up and put under cultivation, the rate at which the organic matter decays is greatly accelerated. Prairie soil when first plowed may contain in some cases more organic matter than is actually necessary for good productivity, but timber soil has such a limited amount of organic matter that its depletion thru cultivation becomes harmful. Special attention must now be given to increasing the amount of this valuable soil constituent in these light-colored soils if the best results are to be expected.

THE SOIL MAP

Basis of Soil Classification

In the soil survey the "type" is the unit of classification. Each soil type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or horizons, which constitute

FIG. 5.—STUDYING THE SOIL PROFILE
Deep natural exposures are made use of in studying the soil profile.

the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. The topography and the kind and character of the vegetation are easily observed features of the landscape which are very useful indicators of soil character. A knowledge of the geological origin and formation of the soil material of the region that is being mapped often makes possible an understanding of the soil conditions which occur.

COUNTY
Blue Ridge
Mansfield
Kenvil
White Heath
CHAMPAIGN COUNTY
Sangamon River
Saline Creek
R 6 E
A Hoen & Co Lithographers Balto Md
36
38
41
56
22
59
66
64
18
17
16
8
134
135
51
107
77
76
73

Not infrequently areas are encountered in which type characters are not distinctly developed or in which such characteristics show considerable variation. When these variations are considered to have sufficient significance, and the areas involved are sufficiently large, type separations are made. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

Naming the Soil Types

In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a somewhat definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise type names which are adequately descriptive, because the profile of mature soils is usually made up of more than one stratum and it is impossible to describe each stratum in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "On," and when its depth exceeds 30 inches, by the word "Over"; for example, Brown Silt Loam On Gravel and Brown Silt Loam Over Gravel.

To assist in designating soil types, a number is assigned to each type. These numbers are not only a convenience in referring to the respective types but they are especially useful in designating very small areas on the map and as a check in reading the map colors.

TABLE 1.—SOIL TYPES OF PIATT COUNTY, ILLINOIS

Soil type No.	Type name	Area in square miles	Area in acres	Percent of total area
36	Light Brown Silt Loam	8.69	5 562	2.08
38	Light Brown Sandy Loam	.20	128	.04
41	Brown Silt Loam	195.89	125 369	45.27
56	Brown Silt Loam On Drift	16.12	10 317	3.72
22	Reddish Brown Silt Loam On Drift	8.11	5 190	1.87
59	Brown Silt Loam On Calcareous Drift	1.11	710	.25
66	Black Clay Loam On Drab Clay	163.90	104 896	37.87
64	Black Clay Loam On Calcareous Drift	8.54	5 465	1.97
18	Brownish Yellow-Gray Silt Loam	9.07	5 805	2.09
17	Brownish Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	5.37	3 437	1.24
16	Brownish Yellow-Gray Silt Loam On Tight Clay	.22	141	.05
8	Eroded Gravelly Loam	2.03	1 300	.47
134	Brownish Yellow-Gray Silt Loam Over Sand Or Gravel	.20	128	.04
135	Brownish Yellow-Gray Sandy Loam Over Sand Or Gravel	.32	205	.07
51	Deep Dark Brown Silt Loam	.25	160	.05
107	Deep Black Clay Loam	.68	435	.15
77	Deep Brown Silt Loam	.09	58	.02
76	Black Mixed Loam	.09	58	.02
73	Brown Mixed Loam	11.84	7 577	2.73
	Total area	432.72	276 941	100.00

Table 1 gives the list of the soil types as mapped in Piatt county, the area of each in square miles as well as in acres, and also the percentage that each type constitutes of the total area of the county.

The accompanying colored map, shown in two sections, gives the location and boundary of each soil type and indicates the position of streams, roads, railroads, and town sites.

DESCRIPTION OF SOIL TYPES

Based on the principles explained above, the soils of Piatt county have been differentiated under nineteen soil types. A brief description of the outstanding characters, together with a few suggestions for the practical management of each type, are given in the following paragraphs.

Light Brown Silt Loam (36)

Light Brown Silt Loam is a relatively unimportant type in Piatt county, occupying a total of only 8.69 square miles, or slightly over 2 percent of the area of the county. It occurs only on slopes or high ground where drainage has always been good and where there has been an accumulation of wind-blown material. It does not occupy the steeper slopes because on such slopes erosion has removed the loess-like material. It occurs on areas sufficiently sloping and high enough to have been well drained but not so sloping that there was much erosion prior to bringing the land under cultivation.

In addition to occupying a characteristic topographic position, the areas of this type are so located as to have received wind-blown material from adjacent low land or silty wash from adjacent higher land. Glacial till is rarely found at depths less than 40 inches from the surface and is commonly found deeper than 50 inches.

The type is characterized by a light brown surface soil which is silty and friable. The surface is 7 or 8 inches deep and passes into a more yellowish material with a reddish cast, which in turn rests on a slightly compact but friable, reddish brown subsoil at a depth of 18 or 20 inches. This subsoil horizon is not very well defined but usually is about 12 to 14 inches thick. Below this subsoil layer, the material becomes much more friable and contains some gray material mixed with the yellow. At depths varying from 40 to about 60 inches, gravelly-sandy glacial till is encountered. This material was deposited by the Wisconsin ice sheet.

Management.—Light Brown Silt Loam is an easy soil to farm, and if reasonable attention is given to keeping it supplied with nitrogen and organic matter it is a productive soil. Failure to practice a good rotation soon results in lowered yields and loss of soil by erosion. This type varies somewhat in acidity, depending on the manner in which it has been farmed and on its location with regard to wash from higher slopes. Ordinarily two tons of limestone, if the stone does not contain too large a proportion of coarse particles, will sweeten the soil sufficiently to grow good red clover and fair sweet clover. After the nitrogen and organic matter have been taken care of by means of a good rotation well handled,

LEG
36 Light Brown Si
38 Light Brown San
41 Brown Silt Loam
56 Brown Silt Loam
22 Reddish Brown S
59 Brown Silt Loam
66 Black Clay Loam
64 Black Clay Loam
18 Brownish Yellow
17 Brownish Yellow
16 Brownish Yellow
8 Eroded Gravelly
134 Brownish Yellow
134B Brownish Yellow
51 Deep Dark Brown
107 Deep Black Clay
77 Deep Brown Silt
76 Black Mixed Loa
73 Brown Mixed Loa
CONVE
Public roads
Paved roads
Private roads
R
R
T
CHAMPAIGN
COUNTY
COUNTY

attention should be given to further improvement by the use of fertilizers. If little manure is available, trial might well be made of either rock phosphate or superphosphate for wheat. The use of either of these materials should benefit the corn crop indirectly thru increased clover growth. Experimental results at present available do not indicate that profitable crop increases in general farming can be expected to follow the use of a complete mixed fertilizer on this soil type.

Light Brown Sandy Loam (38)

Light Brown Sandy Loam is a minor type occupying a total of only two-tenths of a square mile. It differs from Light Brown Silt Loam in having a sandy rather than a silty texture. Where a small patch of this type occurs near the farm dwelling, it may be used for melons or garden crops, for which it is well adapted. The type, unless used for some special purpose, should be managed as recommended for Light Brown Silt Loam (36).

Brown Silt Loam (41)

Brown Silt Loam is the most extensive type in Piatt county, occupying a total of 195.89 square miles, or 45 percent of the area of the county. It occupies intermediate topographic positions and has, for the most part, good surface drainage. The subsoil allows water to pass rapidly into the underdrainage, so that the drainage of this type can be said to be good altho tile must be installed thruout.

The surface soil is about 8 inches thick and has a dark brown color. The subsurface is a somewhat lighter brown than the surface, and the subsoil, which begins at about 18 inches, is a brownish yellow, somewhat compact, clay loam. Below a depth of 35 to 40 inches the material is friable and yellowish in color.

Management.—Erosion should not be a serious problem on this soil, altho, very material damage has been caused by sheet washing on many fields occupied by this type. If good farming methods are practiced, the loss from erosion should be small over most of the type. This soil was originally well supplied with organic matter and still is, except where destructive farming methods have been practiced thru a considerable period of time. Sweet clover or alfalfa will not grow on this type without a light application of limestone, but during favorable clover years red clover will make a fair crop without the addition of limestone. This soil responds well to manure but not so well as Type 36, Light Brown Silt Loam. Where manure is not available, rock phosphate should give profitable returns where clover is grown and used in part as a green manure.

Summarized results from the Bloomington experiment field are given on pages 29 to 33 and may be taken as indicating the returns that may be expected from the use of phosphates.

Brown Silt Loam On Drift (56)

Brown Silt Loam On Drift differs from Brown Silt Loam (41) chiefly in having sandy, gravelly drift near the surface. It occurs in the northeastern corner of the county and on the rolling areas along Sangamon river and occupies a total area of 16.12 square miles. The rolling topography on which this soil

occurs makes it subject to erosion; in fact erosion is responsible for its existence in that it has removed more or less of the original silty surface, thus bringing the sandy gravelly drift near to the present surface. On some slopes erosion has been so active that even the surface soil contains a large amount of gravel.

This type is characterized by a friable, rather coarse silt loam surface soil which is brown in color; a dull reddish brown, somewhat sandy and gravelly silt loam subsurface; and a reddish brown, slightly plastic and medium compact, sandy, gravelly silt loam subsoil. Calcareous material occurs at depths varying from 40 to 60 inches below the surface.

Management.—It is particularly important that a cropping system be adopted for this soil type, that will provide a vegetative cover during as much of the year as possible. The first thing to do in starting such a cropping system is to apply enough limestone so that sweet clover can be grown. Tests show that the lime requirement of this soil varies from 1 to 3 tons an acre with but few areas requiring the maximum amount. Before applying limestone to this soil, tests should be made to determine just how much is needed. Results from the Urbana experiment field indicate that rock phosphate can be used at a profit on this soil tho it would be advisable to grow one or two crops of clover, preferably sweet clover, before investing in this material. Tiling is not commonly practiced on this land but the wise use of tile will prove to be a good investment because of the assistance it gives in decreasing erosion.

Reddish Brown Silt Loam On Drift (22)

Reddish Brown Silt Loam On Drift occurs on rolling to rough topography along Sangamon river. It has supported some timber growth but not for a long enough time to give to it well-developed timber-soil features. This soil has a distinctly reddish cast thruout the profile developed because of its good drainage. Erosion is destructive on this soil.

The surface soil is shallow, has a grayish brown or yellowish brown color, and is often rather sandy because of sheet erosion. The deeper layers are reddish brown and have not developed into well-defined horizons. The fact that it is 50 inches or more to carbonates shows that leaching is rapid in this soil.

Management.—A considerable portion of this type is now used for pasture or timber and these uses should be continued since it erodes badly when farmed. This soil is somewhat peculiar in being more strongly acid in the deeper layers than in the surface. This characteristic appears to be very general over the entire area of the type and suggests that if limestone is applied to improve the pastures more should be applied than is indicated by the degree of acidity of the surface soil.

Brown Silt Loam On Calcareous Drift (59)

Brown Silt Loam On Calcareous Drift occupies a total area of only 1.11 square miles in Piatt county, and occurs only in the northeastern corner of the county on the Blue Ridge moraine. It is found on areas which have suffered the loss of enough soil material by erosion to bring the underlying calcareous drift within 35 inches or less of the surface. It differs from Brown Silt Loam On

Drift (56) chiefly in depth to calcareous material. It is somewhat less acid than Type 56 and is naturally adapted to growing alfalfa because of good drainage and the nearness of carbonates to the surface. Reference may be made to Type 56, page 15, for suggestions regarding the management of this soil.

Black Clay Loam On Drab Clay (66)

Black Clay Loam On Drab Clay is an extensive soil type in Piatt county, occupying a total of 163.9 square miles. It occurs only on low-lying areas and was formed under conditions of poor drainage. These conditions favored the accumulation of organic matter. In places, marl-like material occurs at varying depths below the surface.

The surface soil is black, and is plastic when wet. It is ten or twelve inches in depth, the lower three or four inches often having a waxy appearance. The subsurface is a waxy appearing, black or drabbish black, plastic clay loam. The subsoil, beginning at about 20 inches, is a drab or grayish drab plastic clay.

Management.—This soil type is potentially highly productive. Its characteristics are those imparted by conditions of poor drainage and its present crop-producing value depends on the thoroness with which these conditions have been corrected. The surface drainage of the type is poor, and water does not pass thru the subsoil as readily as it does in the soils previously described. This condition necessitates placing strings of tile not over six rods apart. The physical properties of this soil make it easily injured if worked when too wet or too dry. The moisture range within which it may be successfully worked decreases as the amount of organic matter decreases. It is especially important, therefore, to adopt a cropping system in which provision is made for regular additions of organic matter. This soil type is rarely acid and no assurance can be given that the use of any fertilizing material will return a profit. Drainage and organic matter are the two things which should be given attention at present and probably for many years to come.

Black Clay Loam On Calcareous Drift (64)

Black Clay Loam On Calcareous Drift has a total area of 8.54 square miles in Piatt county. It occupies depressions and is often surrounded by Type 66, just described. It differs from No. 66 in being calcareous at twenty to twenty-five inches below the surface. It is also more difficult to drain than No. 66 and is more likely to be alkaline. However, the same suggestions for management apply to this type that were given for No. 66.

Brownish Yellow-Gray Silt Loam (18)

Brownish Yellow-Gray Silt Loam is a light-colored timber soil occurring along Sangamon river and having a total area of about 9 square miles in this county. The topography of this type is undulating to gently rolling and both the surface drainage and underdrainage are good.

The surface soil is about 8 inches deep and is a grayish light brown silt loam. The subsurface soil is yellowish with a reddish cast and the subsoil, be-

ginning at about 18 inches, is yellowish brown with mottlings of gray and reddish brown. It is slightly compact and slightly plastic but easily permeable to water and roots.

Management.—This soil is medium-acid and is low in organic matter and nitrogen. It responds well to good farming, and following the application of limestone and the growing of sweet clover, produces good yields of corn. Fields which have had their originally small amount of organic matter further reduced by bad farming might well be put into a very short rotation including clover or in a longer rotation in which clover appears twice. No experiment field data are available for this soil type, and because of this fact no recommendations for treatment are made other than the application of limestone in amounts indicated by tests and the use of farm manure and crop residues including clover. After the nitrogen and organic-matter deficiencies have been taken care of, tests should be made with phosphates and other fertilizing materials.

Brownish Yellow-Gray Silt Loam On Compact Medium-Plastic Clay (17)

Brownish Yellow-Gray Silt Loam On Compact Medium-Plastic Clay differs from the type described immediately above, No. 18, because it has developed under conditions of poor drainage. It is found only on flat topography and has poor surface drainage and underdrainage.

The surface soil is a slightly brownish gray silt loam. This horizon, as well as all the horizons in the profile, contains numerous iron pellets. The subsurface, beginning at about 8 inches, is gray splotched with dark brown. The subsoil begins about 17 inches below the surface and is a drabbish gray, compact, medium-plastic clay. This plastic material continues to a depth of 30 to 35 inches, where the material becomes more friable.

Management.—If this soil type is utilized for cropping, attention should first be given to drainage. Tile will draw but not readily; the strings should therefore be placed closer together than in a more open soil. The second step should be to test each field in detail for acidity. This soil is medium to strongly acid but varies somewhat in degree of acidity, hence the desirability of determining by means of detailed tests the exact amount of limestone needed. Following the application of limestone, sweet clover should be seeded and plowed down in the spring of its second year for corn. An objection to this practice is that, particularly on this soil, difficulty may be experienced in getting the plowing done early enough when the spring is wet.

Brownish Yellow-Gray Silt Loam On Tight Clay (16)

Brownish Yellow-Gray Silt Loam On Tight Clay occupies less than a quarter of a square mile in Piatt county and is of relatively low agricultural value. It is similar to No. 17, just described, but the gray color is more pronounced thruout the profile and the subsoil is more impervious. If this soil is farmed, the same general plan should be followed as that recommended for Type 17 except that drainage should be taken care of by means of furrows and open ditches.

Eroded Gravelly Loam (8)

Eroded Gravelly Loam is a minor type occupying a total area of only 2.03 square miles. It occurs in narrow strips on slopes along Sangamon river. Erosion has been sufficiently active on these slopes to remove any loess-like material and expose the glacial drift, which contains a large percentage of gravel. No soil profile has developed because the rate of removal by erosion is more rapid than the rate of soil development. The nature of the material varies somewhat on different slopes because of differences in the glacial drift, some slopes being more sandy or more gravelly than others.

Management.—Eroded Gravelly Loam is unsuited to general farming because of its gravelly nature and because erosion is too severe under tillage. It should be used for timber or pasture, and is well adapted to either of these uses.

Brownish Yellow-Gray Silt Loam Over Sand Or Gravel (134)

Brownish Yellow-Gray Silt Loam Over Sand Or Gravel is a light-colored terrace soil, occupying a total of only two-tenths of a square mile in Piatt county. It differs from type No. 18, the corresponding upland type described on page 17, chiefly in being underlain by sand or gravel. The description and management suggestions given for Type 18 may be applied to this type.

Brownish Yellow-Gray Sandy Loam Over Sand Or Gravel (135)

Brownish Yellow-Gray Sandy Loam Over Sand Or Gravel is a terrace formation and is underlain by sand or gravel. It is of minor importance in Piatt county, occupying only .32 of a square mile. It is not so good a soil as the preceding type, No. 134, but should be managed in the same way.

Deep Dark Brown Silt Loam (51)

Deep Dark Brown Silt Loam is a highly productive soil formed in low-lying areas where much silting-in has taken place. It occupies a total area of only .25 of a square mile in Piatt county. This soil is not acid, is well supplied with organic matter, and needs no fertilizer treatment. It is so youthful that well-defined surface, subsurface, and subsoil horizons have not yet been developed.

Deep Black Clay Loam (107)

Deep Black Clay Loam occurs along Lake Fork creek in the southeastern corner of the county. It is a silted-in type and is therefore deep and shows little horizon development. This soil is highly productive and requires no treatment other than the addition of organic matter as a means of maintaining a good physical condition.

Deep Brown Silt Loam (77)

Deep Brown Silt Loam differs from No. 51, Deep Dark Brown Silt Loam, described above, in having less organic matter. It occupies a total area of only 58 acres in Piatt county.

Black Mixed Loam (76)

Black Mixed Loam occupies so small an area in Piatt county as to be of minor importance. It is similar to Brown Mixed Loam (73) except that it contains much more organic matter. Therefore the reader is referred to Type 73, which is described immediately below.

Brown Mixed Loam (73)

Brown Mixed Loam is the important bottom-land soil in Piatt county. It occupies a total area of nearly 12 square miles. As its name implies, this type is not uniform. There is no well-defined horizon development. The land is productive unless subject to harmful overflow, as much of it is. Corn is the crop usually grown. No treatment need be applied to this soil since practically all of it overflows frequently enough to maintain its productive capacity.

CHEMICAL COMPOSITION OF PIATT COUNTY SOILS

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum, over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.
2. A middle stratum extending from 6⅔ to 20 inches and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling we have represented separately three zones for plant feeding. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore it is the only stratum which can be greatly changed in composition as a result of adding fertilizing materials.

This, of course is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to in describing the soil types as surface, subsurface, and subsoil.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires to consider the information in that form. In comparing the composition of the different strata, it must be kept in mind that the composition of each is based on a different quantity of soil, as explained above. The figures for the middle and lower strata must therefore be divided by two and three respectively before being compared with each other or with the figures for the upper stratum.

TABLE 2.—PIATT COUNTY SOILS:[1] PLANT-FOOD ELEMENTS IN THE UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type[2]	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
36	Light Brown Silt Loam	49 180	4 230	1 010	670	36 350	7 450	7 830
41	Brown Silt Loam	55 740	4 710	1 040	700	34 810	8 310	10 440
56	Brown Silt Loam On Drift	50 600	4 430	1 070	.....	36 500	8 470	8 820
59	Brown Silt Loam On Calcareous Drift	47 390	4 210	1 000	.....	37 820	8 340	7 600
66	Black Clay Loam On Drab Clay	75 900	6 940	1 800	1 050	34 230	14 890	24 660
64	Black Clay Loam On Calcareous Drift	63 220	6 310	1 580	910	35 910	14 950	21 190
18	Brownish Yellow-Gray Silt Loam	23 800	2 100	760	520	35 820	5 860	7 050
17	Brownish Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	25 740	2 230	790	440	33 470	5 320	7 150
134	Brownish Yellow-Gray Silt Loam Over Sand Or Gravel	27 050	2 270	1 130	420	37 000	5 920	7 750

[1]The samples representing the respective types were taken mainly in neighboring counties.
[2]No samples were taken of Types 107, 77, 76, and 73, on account of their heterogeneous character, nor of Nos. 38, 22, 16, 8, and 135, on account of their limited areas.

Dark-Colored Soils High in Organic Matter and Nitrogen

Among the outstanding features of the chemical make-up of these soils is the gradation in the quantity of organic matter as one passes from the dark- to the light-colored soils. The organic carbon, which constitutes about 50 percent of the organic matter and is used as a measure of organic matter, varies in the surface soil from 75,900 pounds an acre in Black Clay Loam On Drab Clay to less than one-third this amount, or 23,800 pounds in Brownish Yellow-Gray Silt

TABLE 3.—PIATT COUNTY SOILS:[1] PLANT-FOOD ELEMENTS IN THE MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type[2]	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
36	Light Brown Silt Loam	70 960	6 630	1 850	1 080	72 790	17 990	15 760
41	Brown Silt Loam	69 940	6 240	1 700	1 140	70 260	20 460	19 730
56	Brown Silt Loam On Drift	71 410	6 400	1 770	.....	74 440	21 520	17 930
59	Brown Silt Loam On Calcareous Drift	62 600	5 910	1 600	.....	79 730	21 170	15 320
66	Black Clay Loam On Drab Clay	69 270	6 620	2 690	1 400	70 760	31 870	41 910
64	Black Clay Loam On Calcareous Drift	59 300	5 900	2 500	1 200	72 620	33 190	37 810
18	Brownish Yellow-Gray Silt Loam	17 660	2 190	1 380	560	73 620	21 340	14 490
17	Brownish Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	16 900	1 830	1 160	760	70 160	19 410	13 560
134	Brownish Yellow-Gray Silt Loam Over Sand Or Gravel	19 700	2 240	2 060	920	76 640	15 440	13 360

[1]The samples representing the respective types were taken mainly in neighboring counties.
[2]No samples were taken of Types 107, 77, 76, and 73, on account of their heterogeneous character, nor of Nos. 38, 22, 16, 8, and 135, on account of their limited areas.

TABLE 4.—PIATT COUNTY SOILS:[1] PLANT-FOOD ELEMENTS IN THE LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type[2]	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
36	Light Brown Silt Loam	45 800	4 260	2 100	1 140	114 680	39 080	27 320
41	Brown Silt Loam	35 370	3 780	2 250	1 020	108 240	46 900	42 220
56	Brown Silt Loam On Drift	36 010	4 080	2 260	.....	114 700	43 040	28 460
59	Brown Silt Loam On Calcareous Drift	34 810	3 720	1 870	.....	131 730	48 460	41 740
66	Black Clay Loam On Drab Clay	33 270	3 490	3 130	1 100	109 040	62 640	98 950
64	Black Clay Loam On Calcareous Drift	36 230	3 770	2 900	1 200	106 940	77 430	184 030
18	Brownish Yellow-Gray Silt Loam	10 960	2 580	2 300	550	112 300	45 360	31 300
17	Brownish Yellow-Gray Silt Loam On Compact Medium-Plastic Clay	20 320	2 550	2 340	1 140	110 950	40 240	28 090
134	Brownish Yellow-Gray Silt Loam Over Sand Or Gravel	15 000	2 130	3 180	720	106 860	33 330	22 380

[1]The samples representing the respective types were taken mainly in neighboring counties.
[2]No samples were taken of Types 107, 77, 76 and 73, on account of their heterogeneous character, nor of Nos. 38, 22, 16, 8, and 135, on account of their limited areas.

Loam. It will be noticed that the nitrogen content of these soils runs approximately parallel to the organic carbon, being about one-eleventh as high. This relationship is explained by the fact that nearly all the soil nitrogen is organic nitrogen, that is, it is a part of the organic matter. One of the important biological processes associated with the decay of organic matter is the conversion of the organic nitrogen into the inorganic form of nitrate, thus making it available to growing crops.

Phosphorus and Sulfur Associated With Organic Matter

Two other chemical elements, phosphorus and sulfur, both essential for plant growth, are associated with the organic matter of the soil tho less completely so than is nitrogen. Altho variations occur with different soils, it is estimated that in general one-fourth to one-third of the total phosphorus in ordinary soils exists as organic phosphorus. Less is known of the proportion of the sulfur found in organic forms. However, the amount of organic matter in a soil is a rough index of the abundance of these various elements, all of which are associated in a greater or less degree. Thus, Types 64 and 66 are the highest in organic carbon, with more than 60,000 pounds an acre. These types contain somewhat more than 6,000 pounds an acre of nitrogen, 1,500 to 1,800 pounds of phosphorus, and about 1,000 pounds of sulfur. A second group of soils is represented by Types 36, 41, 56, and 59. These average about 50,000 pounds an acre of organic carbon, about 4,500 pounds of nitrogen, 1,000 pounds of phosphorus, and 700 pounds of sulfur. The lowest group, represented by Types 17, 18, and 134 contains from one-half to two-thirds as high a percentage of these four related elements as the soils of the second group.

In passing to the middle and lower soil strata, the organic matter, together with these associated elements, decreases in amount, the decrease being less in the case of phosphorus and sulfur, which exist in part in mineral form.

The quantities of sulfur in the various soils are considerably lower than those of phosphorus. While crops in general take more sulfur than phosphorus from the soil, the atmospheric supply prevents sulfur deficiencies from developing. The sulfur dioxid which escapes into the air in the burning of wood and coal is brought to the earth dissolved in rain water, the amount added to the soil ranging in different parts of the state from one to three or more pounds of sulfur an acre a month.

Potassium Content Comparatively Uniform

The potassium content of Piatt county soils shows relatively less variation from type to type than any other element studied. The average amount in the surface soil is approximately 35,770 pounds an acre, and the entire range thru all the types in the county is from 33,470 to 37,820 pounds an acre. The potassium concentration in the soil at different depths likewise shows very little variation, averaging 36,720 pounds an acre in the middle stratum, and 37,600 pounds in the lower, when the figures are converted to the basis of 2 million pounds per acre.

Wide Variations in Calcium and Magnesium

Variations in the calcium and magnesium content of Piatt county soils are almost as great as those in the organic matter, as can be seen from Tables 2, 3, and 4.

Aside from the calcium which may be in solution in the soil water, soil calcium exists primarily in three forms. *Calcium-aluminum silicates* are complex soil minerals which decompose but slowly and furnish but scant amounts of soluble calcium for plant growth. This is the form which predominates in most soils, particularly those which are highly acid. Calcium may be deficient as a plant-food element in such soils, so that the supplying of this element may be one of the benefits of liming. Calcium also occurs in association with the soil colloids (the finest of the clay particles), where it is absorbed; this is known as *replaceable calcium*, and is much more easily obtainable by growing plants than the mineral form above mentioned. It is found more abundantly in the soils which are non-acid or only slightly acid. Soil types are occasionally found that grow sweet clover luxuriantly because of the abundance of replaceable calcium which they contain, even tho they may be distinctly acid. *Calcium carbonate*, the form contained in limestone, is the third form of calcium in soils. It occurs only in alkaline (sweet) soils. Of the three forms of calcium this is the most readily dissolved in the soil water; it is carried down to lower levels, where it tends to accumulate. The depth at which carbonates are found varies with the amount of leaching to which the soil has been subjected. While calcium carbonate is not present in the surface soils of Piatt county, it may be encountered within the upper 40 inches in a few soil types.

As the calcium and the magnesium in the soil water are carried downward, magnesium is more readily absorbed than calcium by the soil colloids, so that

with increasing depth there is an increasing proportion of magnesium to calcium. This change is the more pronounced in mature soils. For example, in Type 17 the ratios of magnesium to calcium in the upper, middle, and lower strata are, respectively, .74, 1.43, and 1.43. That is, in the surface soil there is only about three-fourths as much magnesium as calcium, while in the second and third strata there is about one and one-half times as much magnesium as calcium. In youthful soils, where the leaching has been less intense or less prolonged, the ratio of magnesium to calcium shows little or no increase in the lower levels. For instance, in Black Clay Loam On Drab Clay the ratios of magnesium to calcium are, in the three respective strata, .60, .76, and .63.

From these observations, it is obvious that some of the various processes involved in soil development are definitely reflected in the chemical properties of the soil itself. These, in turn, may be related to agricultural utilization and fertility requirements.

Local Tests for Soil Acidity Often Necessary

It is impracticable to attempt to obtain an average quantitative measure of the calcium-carbonate content or the acidity of a given soil type because, while some samples will contain large amounts of calcium carbonate (as in some subsoils of Piatt county), others will contain none, but on the other hand, may actually have a lime requirement due to the soil acidity. We thus have what may be considered positive and negative values ranging, perhaps widely, on the opposite sides of the zero or neutral point. The numerical average of such values could have no significance whatever, since such an average would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types.

The qualitative field tests made during the process of the soil survey are much more numerous than the chemical analyses made in the laboratory, and they give a general idea of the predominating condition in the various types as to acidity or alkalinity. These tests therefore furnish the basis for some general recommendations which are given in the descriptions of individual types on pages 14 to 20. To have a sound basis for the application of limestone, the owner or operator of a farm will usually find it desirable to determine the lime requirements of each of his different fields. The section in the Appendix dealing with the application of limestone (page 41) is pertinent and should be read in this connection.

Chemical Combinations of Plant-Food Elements in Relation to Their Availability

It has been seen that a given plant-food element exists in the soil in various forms, or chemical combinations. Thus the soil phosphorus is partly organic and partly in several different inorganic, or mineral, combinations. These various forms differ from each other in the rates at which they become available to growing crops. Again, calcium has been observed to be present sometimes as

calcium carbonate, which is quickly available in the soil, but it is generally more abundant as *replaceable calcium,* a form which is not so active yet is more or less available; and it is also present as *calcium-alumino-silicate* minerals, which decompose very slowly. Statements of similar import might be made concerning nitrogen, sulfur, and other elements. Moreover, the proportions in which the different forms of a given element occur vary in different soils. When the importance of the rate at which plant-food elements become available is considered in the light of these facts, it becomes apparent that a knowledge of the total amounts of these various elements present in a soil cannot be a very definite guide as to the need for applications in the form of fertilizers.

Service of Chemical Investigations in Soil Improvement

The chemical investigations carried out in connection with the soil survey, of which the analyses here reported are a part, are of value chiefly in two ways: In the first place, they reveal at once outstanding deficiencies or other chemical characteristics which alone would affect soil productivity to a marked extent, or point the way to corrective measures. It should be borne in mind, however, that fairly wide departures from the usual composition are necessary before the chemical analysis alone can be followed as a guide in practice without supplementary information from other sources. It is probable that the results of chemical soil analyses are frequently misused when attempts are made to interpret small differences in the amount of a certain plant-food element as indicative of corresponding differences in the fertilizer need. For example, differences of 100 or 200 pounds of phosphorus an acre in soils containing 1,000 pounds or thereabout in the surface soil should not be considered as indicating that there will be a corresponding difference in response to phosphate fertilization. Again, 100 pounds of active nitrogen an acre added by plowing down a clover crop may be of more importance to the succeeding crop than a difference in soil composition of 1,000 pounds of nitrogen an acre. As an example of the direct use of the results of chemical investigations the case of the need for potassium fertilization in peat soils as revealed by chemical analysis may be cited; another case is the determination of the lime need of soils by chemical tests.

The second place in which chemical methods are useful is in the more detailed study of soils. The processes of soil development leave their imprint both in the physical conformation of a soil and in its chemical characteristics. Likewise every operation in the handling of the soil and every application of fertilizer or liming material disturbs its equilibrium, setting up new reactions, which are in turn reflected in variations in crop adaptability, producing capacity, and agricultural usefulness. Chemistry is a most important tool in tracing and characterizing such changes, and chemical investigations are undertaken with the aim of aiding in the classification of soils as well as making possible more accurate prediction of their agricultural value and fertility needs and their response to different methods of management.

FIELD EXPERIMENTS ON SOIL TYPES SIMILAR TO THOSE IN PIATT COUNTY

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various soil types. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on soil types described in this soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement of Fields

The soil experiment fields vary in size from less than two acres up to forty acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with each crop represented every year.

Farming Systems

On most of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

In the livestock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system, but certain modifications have been introduced in recent years, as explained in the descriptions of the respective fields.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots at the beginning was usually standardized according to a rather definite system. With advancing experience, however, new problems arose calling for new experiments, so that on most of the fields plots

have been divided and a portion given over to new systems of treatment, at the same time maintaining the original system essentially unchanged from the beginning.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—Limestone has usually been applied at the rate of 4 tons an acre as an initial application, and 2 tons an acre every four years thereafter until a considerable excess has accumulated in the soil. Rock phosphate has been applied at the rate of one ton an acre at the beginning, followed by an annual acre-rate of 500 pounds applied once in the rotation until a considerable excess has accumulated. Potassium has been applied usually in the form of 200 pounds of kainit a year. When kainit was not available, owing to conditions brought on by the World War, potassium carbonate was used.

Explanation of Symbols Used

Following is a key to the symbols used in describing soil treatments and reporting results from their use.

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus, in the form of rock phosphate unless otherwise designated. (sP=superphosphate, bP=bone meal, rP=rock phosphate, slP=slag phosphate)
K = Potassium (usually in the form of kainit)
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed

DIXON FIELD

A summary of the results from the Dixon experiment field are presented here, inasmuch as the soil of this field is similar to some of that found in Piatt county. (See discussion of Light Brown Silt Loam, page 14). This field includes about 21 acres and is laid out into two general systems of plots, a major and a minor system. The results from the major system will be considered here.

The rotation practiced has been wheat, corn, oats, and clover. The treatment of the plots and management of the crops were, for the most part, maintained up to 1922 according to the general plan described on pages 26 and 27. The most important modification of the plan has been the discontinuance, within the last

FIG. 6—CLOVER ON UNTREATED LAND, DIXON FIELD
A cutting of red-clover hay obtained from an untreated plot. Compare with the crop shown in Fig. 7.

few years, of the applications of limestone, phosphate, and straw residues, after the total quantity of limestone applied had reached the average amount of 8 tons an acre and the total phosphate 4 tons an acre.

Table 5 gives a summary of the results in terms of the average annual crop yields obtained since the plots have been under complete treatment.

In considering these results, the most striking feature to be observed is the outstanding effect of farm manure. The average annual increase due to the use of manure alone has amounted to over 19 bushels of corn an acre, more than 14 bushels of oats, 6½ bushels of wheat, nearly ¾ of a ton of clover, and ¼ of a ton of soybean hay.

Organic manure in the form of crop residues has also produced increases in yields altho not to the extent of those produced by animal manure.

TABLE 5.—DIXON FIELD: SUMMARY OF CROP YIELDS
Average annual yields, 1912-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *14 crops*	Corn *18 crops*	Oats *17 crops*	Barley *1 crop*	Clover[1] *11 crops*	Soybeans *5 crops*
1	0	20.8	37.1	48.2	43.3	(1.79)	(1.50)
2	M	27.3	56.4	62.4	46.4	(2.47)	(1.75)
3	ML	31.3	61.2	66.3	55.2	(2.67)	(1.87)
4	MLP	34.1	63.7	68.0	58.3	(2.80)	(1.91)
5	0	22.3	41.8	54.1	49.5	(1.49)	(1.27)
6	R	25.1	48.8	57.2	53.8	(1.56)	(1.43)
7	RL	28.5	56.6	62.1	54.5	(1.89)	(1.40)
8	RLP	32.5	58.0	64.4	59.0	(2.12)	(1.38)
9	RLPK	33.6	61.9	63.9	56.9	(2.24)	(1.42)
10	0	20.7	40.8	51.2	45.4	(1.90)	(1.46)

[1] Including some seed evaluated as hay.

FIG. 7.—CLOVER ON TREATED LAND, DIXON FIELD

A cutting of red-clover hay produced under the residues-limestone-phosphate treatment. Here we have a yield of 1,319 pounds, more than two and one-third times the yield on the untreated land.

Limestone in addition to organic manures has, with a single exception, effected more or less improvement. On the whole it has become increasingly profitable, so that in the last rotation period it has returned a net profit of $5.50 per ton of limestone in the manure system and $7.00 in the residues system.

Rock phosphate, as usual, shows up to best advantage when used with residues on the wheat crop. The effect on other crops, however, has been such that the increases in yield are not sufficient to cover the cost of the application under existing market conditions.

Altho potassium has produced an average increase of about 4 bushels an acre in corn, the effects on other crops are such as to render its use unprofitable in growing these common field crops.

BLOOMINGTON FIELD

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat; and, since 1905 they have been grown in the sequence named.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. For twenty years all the phosphorus on this field was applied in the form of steamed bone meal at the rate of 200 pounds an acre a year.

Table 6 presents a summary of the work to 1923 by average annual yields. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they were applied.

TABLE 6.—BLOOMINGTON FIELD: SUMMARY OF CROP YIELDS
Average annual yields 1902-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*	Clover[1] *3 crops*
1	0	44.6	40.6	26.5	(.74)
2	L	41.5	44.7	24.1	(.80)
3	LR	47.5	46.2	27.9	(.88)
4	LbP	55.8	54.3	45.7	(2.54)
5	LK	46.2	43.5	25.5	(.90)
6	LRbP	60.6	66.0	49.7	(1.19)
7	LRK	48.6	46.8	27.5	(.82)
8	LbPK	60.9	57.2	44.5	(2.44)
9	LRbPK	64.2	63.1	50.4	(.81)
10	RbPK	58.8	52.8	49.3	(.83)
	Crop Increases				
For limestone					
L	over 0	− 3.5	4.1	− 2.4	(.06)
LRbPK	over RbPK	5.4	10.3	1.1	−(.02)
For residues					
LR	over L	6.0	1.5	3.8	(.08)
LRbP	over LbP	4.8	11.7	4.0	−(1.35)
LRK	over LK	2.4	3.3	2.0	−(.08)
LRbPK	over LbPK	3.3	5.9	5.9	−(1.63)
For phosphorus					
LbP	over L	14.3	9.6	21.6	(1.74)
LRbP	over LR	13.1	19.8	21.8	(.31)
LbPK	over LK	14.7	13.7	19.0	(1.54)
LRbPK	over LRK	15.6	16.3	22.9	−(.01)
For potassium					
LK	over L	4.7	− 1.2	1.4	(.10)
LRK	over LR	1.1	.6	− .4	−(.06)
LbPK	over LbP	5.1	2.9	− 1.2	−(.10)
LRbPK	over LRbP	3.6	− 2.9	.7	−(.38)

[1]Two crops of seed on Plots 3, 6, 7, and 9 evaluated as hay.

The value of limestone on this field is difficult to assess on account of the erratic results found upon comparing Plots 1 and 2. Here both corn and wheat appear to have suffered from the application of limestone, but the difficulty may well be attributable to soil variability. Comparing Plots 9 and 10, it would appear that in combination with residues, phosphorus, and potassium, the limestone on the whole was beneficial.

The residues treatment, supplying organic matter and nitrogen, shows a beneficial effect on the grain crops, but not on the clover.

The prominent feature of the results on the Bloomington field is the effect of phosphorus. In all of the grain crops, on every plot where bone meal was applied, there was a remarkable response to the treatment, as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues, with limestone, residues, and phosphorus) we find that the phosphorus treatment produced an average annual increase in the yield of corn of

about 13 bushels an acre, while the yield of oats was increased by about 20 bushels, and that of wheat by about 22 bushels. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8, where potassium instead of residues was present.

Quite different are the results from the use of potassium on this field. The potassium was applied mainly in the form of potassium sulfate, but in 1917 when this material became unavailable thru war conditions, potassium carbonate was substituted. There was a moderate increase in the corn yield where potassium was used and particularly where residues were absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is the outstanding limiting factor in production and the application of this element in the form of steamed bone meal is attended by a high financial profit.

New Phosphate Experiments

In view of this remarkable response to bone meal on the Bloomington field, it was of interest to know how other carriers of phosphorus would behave, and accordingly some experiments were planned to investigate this question. For this purpose, the plots were divided in 1924 and certain new treatments were applied in order to compare the effects of rock phosphate and of superphosphate with bone meal, and at the same time to determine the residual effect of the accumulated phosphorus resulting from the continuous application of the bone meal in presumably somewhat excessive amounts. The following modifications of the original plots were introduced:

An extra plot, No. 11, was added to the series and all plots were divided into north and south halves. Residues, including cornstalks, the second crop of red clover, and other leguminous green manure crops are plowed down on all plots except Plot 1-S. Different phosphorus carriers are applied at the following acre-rates per rotation: bone meal, 1,000 pounds, to Plots 2-N, 4-N, 6-N, 8-N, 9-N, and 10-N; rock phosphate, 2500 pounds, to Plots 3-N, 5-N, 7-N, and 11-N; superphosphate, 1,000 pounds, to Plots 3-S, 5-S, 7-S, and 11-S. Two-fifths of the rotation application of these phosphates is made preceding the oats crop, two-fifths ahead of the wheat crop, and one-fifth in preparation for the corn crop.

Table 7 indicates the arrangement of these modified plots and also gives the results of the six years in which these later experiments have been in progress.

In arriving at the financial results presented in the table, the values of the crops are based upon December 1 farm price quotations for the years in which the respective crops were produced. In deducting the annual cost for the different treatments, the total amounts of materials applied during the entire period of operation on the field were prorated excepting in the case of the new phosphate applications, for which the regular annual acre-rate is charged. The expense for limestone is reckoned here at $3 a ton, rock phosphate at $15, superphosphate at $32, bone meal at $48, potash estimated as potassium sulfate at $70, and residues at 75 cents an acre.

TABLE 7.—BLOOMINGTON FIELD: NEW PHOSPHATE EXPERIMENTS
Crop yields and values 1924-1929—Bushels or (tons) and dollars per acre

Plot No.	Soil treatment		1924	1925	1926	1927	1928	1929	Average annual acre-value		
	Previous	Present	Oats	Clover	Wheat	Corn	Corn	Oats	Gross	Cost of treatment	Net
1-N	0	R	60.6	(.79)	29.3	49.8	49.0	62.8	$28.59	$ .75	$27.84
1-S	0	0	58.4	(2.54)	19.5	41.0	33.4	60.3	28.04	.....	28.04
2-N	L	RLP (bone)	72.6	(1.63)	35.0	58.6	52.2	60.6	34.19	6.49	27.70
2-S	L	RL	53.2	(.75)	18.7	46.0	35.2	51.6	22.95	1.69	21.26
3-N	RL	RLP (rock)	68.2	(2.18)	32.5	63.6	64.6	57.2	36.60	3.57	33.03
3-S	RL	RLP (super)	71.3	(1.74)	41.0	67.6	59.6	66.9	37.95	4.89	33.06
4-N	LP (bone)	RLP bone)[1]	57.6	(1.81)	37.3	60.0	49.6	58.4	33.67	6.49	27.18
4-S	LP (bone)	RLP (bone)[2]	67.2	(1.89)	36.7	63.6	60.0	65.0	36.59	5.17	31.42
5-N	LK	RLKP (rock)	63.2	(1.66)	32.5	61.4	56.2	57.2	33.59	6.17	27.42
5-S	LK	RLKP (super)	78.4	(1.59)	40.7	69.4	55.6	65.3	36.90	7.49	29.41
6-N	RLP (bone)	RLP (bone)[1]	68.8	(2.18)	40.5	60.8	55.8	66.9	37.57	6.49	31.08
6-S	RLP (bone)	RLP (bone)[2]	71.6	(2.21)	40.0	64.2	60.4	73.4	39.13	5.17	33.96
7-N	RLK	RLKP (rock)	71.2	(2.11)	35.3	66.4	58.4	64.1	37.29	6.17	31.12
7-S	RLK	RLKP (super)	80.9	(1.66)	40.7	74.8	62.8	69.4	39.82	7.49	32.33
8-N	LKP (bone)	RLKP (bone)[1]	60.9	(1.69)	39.2	67.4	56.2	64.1	36.02	9.09	26.93
8-S	LKP (bone)	RLKP (bone)[2]	65.0	(1.59)	36.0	69.4	63.0	70.9	36.91	7.77	29.14
9-N	RLKP (bone)	RLKP (bone)[1]	60.9	(2.18)	43.8	75.8	60.4	67.2	39.95	9.09	30.86
9-S	RKLP (bone)	RLKP (bone)[2]	72.2	(1.65)	41.5	77.8	62.6	71.6	39.75	7.77	31.98
10-N	RKP (bone)	RKP (bone)[1]	48.2	(1.93)	45.7	56.6	51.2	60.3	34.87	8.15	26.72
10-S	RKP (bone)	RKP (bone)[2]	51.2	(1.53)	43.0	60.6	58.0	68.4	35.31	6.83	28.46
11-N	([3])	RP (rock)	70.4	(1.68)	45.3	61.8	47.4	60.6	36.06	2.63	33.43
11-S	([3])	RP (super)	60.0	(1.78)	44.5	63.0	57.2	69.7	37.24	3.95	33.29

[1]Bone meal applications omitted from 1917 to 1924. [2]No bone meal applied since 1917. [3]New plot added in 1924

It should be mentioned in considering the results that the soil of these plots is rather variable, with little provision for duplication; and also, that some of the treatments are not now strictly comparable with one another on account of the previous history of the plots. Nevertheless, making allowances for these facts, certain figures in the last column of the table showing the net average acre value per year indicate effects worthy of consideration.

In answering the question whether other carriers of phosphorus would be as effective as bone meal in building up this soil, attention is called to the results on Plots 2-N, 3-N, and 3-S, where bone meal, rock phosphate, and superphosphate respectively have been employed in addition to limestone and residues. Unfortunately the comparison here is not altogether perfect in that the residues treatment on Plot 2-N was not introduced until 1924, whereas the other two plots had been under residues in the old system before the present experiments were begun and may therefore have an advantage in this respect over the bone-meal plot. However this may be, the results as they stand at present place both rock phosphate and superphosphate ahead of bone meal.

Between rock phosphate and superphosphate four direct comparisons in different combinations with other materials are afforded (Plots 3, 5, 7, and 11). In some years on some plots the results are in favor of superphosphate; in other years on the same plots the reverse is true. As the results stand at present the majority are in favor of superphosphate, but their inconsistency makes it difficult to come to any final conclusion. It may be noted that in these comparisons the two materials are not applied in amounts proportionate to equal cost as in other cases reported. Here 200 pounds an acre a year of superphosphate figured at $3.20 are applied against 500 pounds of rock phosphate valued at $3.75 an acre a year.

For light on the question of the residual effect of accumulated phosphorus in the soil, attention is called to the results on Plots 4, 6, 8, 9, and 10, where the north half-plots are now regularly receiving bone meal, and where the south halves have received no bone meal since 1917. Invariably the net return is higher on the south half, thus indicating that the reserve phosphate accumulated in the soil from previous applications is still exerting a beneficial effect that is more than adequate to offset the expense involved in renewed applications.

By way of a summary of the main lessons brought out at this time by the Bloomington experiments, the following statements may be made.

1. The results indicate an outstanding phosphorus hunger.
2. This phosphorus need is satisfied by the application of either bone meal, rock phosphate, or superphosphate.
3. There is a pronounced residual effect from previous excessive applications of phosphorus carried in the form of bone meal.

MORROW PLOTS

As representing the soil type Brown Silt Loam, the field experiments on the Morrow plots, which have been continued for more than half a century, will be of special interest.

The Morrow plots are located on the campus of the University of Illinois. This series now consists of three plots divided into halves, and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904. Besides farm manure, phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. In 1925 the phosphates were evened up to a total of 3,300 pounds of bone meal and 13,200 pounds of rock phosphate and their application discontinued. In 1904 ground limestone was applied at the rate of 1,700 pounds an acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons an acre. From 1903 until 1920 legumes were seeded in the corn on the south half

FIG. 8.—CORN ON THE MORROW PLOTS IN THE THREE-YEAR ROTATION

Both of these plots are under a good crop rotation of corn, oats, and clover. No soil treatment is applied to the plot at the left, while that at the right receives manure, limestone, and phosphate. The one is yielding at the rate of 49 bushels an acre, the other at 67 bushels.

of each plot. Legumes, chiefly red clover until 1918 and sweet clover since that time, have been seeded in the oats on the south half of Plot 4.

Summarizing the data from these Morrow plots into two periods, with the second period beginning in 1904, when the treatment began on the half-plots, some interesting comparison are brought out in Table 8. In the first place we find in the untreated, continuous-corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production. The averages for the three-year system on the untreated land show a slight increase in corn yield, a small decrease in oats, and a considerable reduction in clover.

Crop rotation has noticeably improved the yields over continuous corn growing. The three-year rotation has been more effective than the two-year rotation in maintaining yields over the entire period. The two-year rotation, however, has been gaining on the three-year rotation in recent years probably because of the influence of sweet clover.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization. Thruout the season the crops growing on the treated soil are usually

TABLE 8.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY

Average annual yields—Bushels or (tons) per acre

Years	Soil treatment	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
1888 to 1903		*16 crops*	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
	None	39.7	41.0	44.0	48.0	47.6	(2.03)
1904 to 1929		*26 crops*	*13 crops*	*13 crops*	*9 crops*	*9 crops*	*8 crops*
	None	24.7	34.2	34.0	49.3	46.3	(1.49)
	MLP	40.0	60.9	59.2	67.2	64.1	(2.83)

at a more advanced stage of development than those growing on the untreated soil. In corn this shows up at husking time in drier, sounder ears than those found on the untreated land.

An important principle of soil management is demonstrated in these experiments; namely, that the best results are not obtained thru crop rotation alone nor thru soil fertilization alone, but it is the combination of these two practices that brings out the highest possibilities for production.

The practices in rotation and soil treatment which have been the most effective in increasing the crop-producing capacity of the soil have also been in this case the most profitable financially. These better practices not only have increased the yields but they have made possible a greater economy in production, an important factor in increasing farm profits.

For further information concerning these long-time soil experiments, the reader is referred to Bulletin 300, "Lessons from the Morrow Plots," where these investigations are described and discussed in detail.

HARTSBURG FIELD

More than one-third of the area of Piatt county is occupied by soil somewhat similar to the Black Clay Loam upon which the Hartsburg experiment field is located. This field is situated in Logan county just east of the town of Hartsburg and has been in operation since 1911.

The field is laid off in five series of ten plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series. The crops were handled mainly as described on pages 26 and 27 until 1918, when it was planned to remove one hay crop and one seed crop of clover from the residues plots. In 1921 it was decided to harvest all the clover as hay. At that time the return of the oat straw to the land was discontinued. In 1922 the return of the wheat straw was likewise discontinued. The application of limestone was discontinued in 1922, after amounts ranging from 7½ to 10 tons an acre on the different series had been applied, and no more will be added until further need for it becomes apparent. In 1923 the phosphate applications were evened up to a total of 4 tons an acre on all phosphate plots, and no more will be applied for an indefinite period. At that time the rotation on the first four series was changed to corn, corn, oats, and wheat with a seeding of hubam clover in the oats on all plots and a seeding of biennial sweet clover in the wheat on the residues plots. The rotation was changed also on the fifth series to corn, oats, wheat, and a mixture of alfalfa with red clover. The soil treatments are as indicated in Table 6, which summarizes by crops the yields for the period during which the plots have been under full treatment.

The outstanding feature of the results on the Hartsburg field is the large increases produced by organic manure, whether in the form of crop residues or stable manure. The behavior of limestone is rather peculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure it has caused some increase in practically all crops, while with residues its effect on several of the crops appears negative.

TABLE 9.—HARTSBURG FIELD: SUMMARY OF CROP YIELDS
Average annual yields 1913-1929—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Wheat *15 crops*	Barley *1 crop*	Corn *26 crops*	Oats *18 crops*	Clover *8 crops*	Soy-beans *2 crops*	Alfalfa *8 crops*	Stubble clover *3 crops*
1	0	24.6	35.4	46.4	47.8	(1.86)	(1.29)	(3.47)	(.62)
2	M	27.6	44.2	56.5	52.1	(2.21)	(1.64)	(3.67)	(.82)
3	ML	33.6	50.0	63.8	57.8	(2.35)	(1.82)	(3.91)	(.74)
4	MLP	35.4	50.0	62.8	56.9	(2.43)	(1.92)	(4.19)	(.83)
5	0	28.0	42.7	51.2	46.8	(1.66)	25.8	(3.33)	(.58)
6	R	31.1	47.5	62.9	52.4	(2.00)	26.8	(3.78)	(.96)
7	RL	28.8	53.3	66.6	50.9	(1.99)	28.4	(3.45)	(.72)
8	RLP	33.0	46.9	66.9	54.7	(2.04)	26.1	(4.04)	(.93)
9	RLPK	32.6	55.6	65.4	54.1	(1.99)	26.4	(4.16)	(1.04)
10	0	29.1	45.8	51.7	47.4	(2.09)	(1.69)	(3.20)	(.54)

Altho rock phosphate has given some increases in wheat yield in both the manure and the residues systems, the results with other crops have been such as to render the use of this material unprofitable on this field. The addition of potassium appears to have produced no significant effect except on the one barley crop.

APPENDIX

PRINCIPLES OF SOIL MANAGEMENT

Clear thinking on the complex problems of soil management must start with a realization that there are many different kinds of soils, each differing from the others in soil characters. The fertilizer, management, and cropping requirements of each kind of soil are not yet fully worked out, altho knowledge regarding the agricultural significance of the various soil types recognized in the soil survey is rapidly accumulating.

Soils are dynamic, exceedingly complex, natural bodies made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, soils cannot be considered as reservoirs into which given quantities of an element or elements of plant food can be poured with the assurance that they can be expected to respond uniformly to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance to favor the growth of higher plants and of beneficial microorganisms.

It is obvious that in order to fulfill these conditions no single system of soil treatment can be laid down for all situations. The long-time records from numerous soil experiment fields scattered over Illinois demonstrate strikingly that different soils require different management practices. Some soils are naturally so productive that no fertilizer treatment yet tried has succeeded, on a paying basis, in raising the crop yields over their natural capacity. On the other hand, there are other soils so poor that altho under proper treatment the yield can be increased many fold, the plane of production under the best management known is still so low that it is questionable whether it pays to farm the land at all. Between these two extremes all grades of productivity are found. A further significant fact brought out in a study of these experiment fields is that a given piece of land seldom responds to soil treatments in the same manner thruout its history. The most efficient treatment during one rotation period does not necessarily remain the most efficient in another period.

Thus it appears that soil management is a complex matter even when considered from only one side of the problem, namely, that of producing crops. In addition to these complexities connected with production, however, are those having to do with the everchanging economic conditions by which market prices are affected. Whether a certain yield produced by a given soil treatment will be profitable depends directly upon the price of produce as well as upon the cost of the treatment, and every farmer knows only too well something of the violent fluctuations in market prices that have taken place in recent years. Furthermore, costs of fertilizing materials change from time to time, and these changes do not necessarily run parallel with the fluctuations in value of farm products.

With these facts in mind it is not difficult to understand that, from the standpoint of financial profits, a soil-management practice perfectly recommendable this year may become wholly unprofitable in another year and, vice versa, a practice that is unprofitable under present conditions may become highly profitable at another time.

The above remarks suggest something of the difficulty of prescribing definite recommendations for specific soil treatments and of the futility of making blanket recommendations to cover the requirements of all soils and all crops at all times. In mentioning these difficulties there is no intention to discourage efforts at planning programs of soil improvement; the purpose, rather, is to set forth some of the uncertainties involved and, in particular, to warn against hasty conclusions based upon scanty experience or superficial observation.

In spite of the many complexities involved in the problem of soil improvement, there are certain broad, underlying principles that are basic and that must be taken into consideration in laying out any improvement program. Underlying the permanent and profitable productivity of the soil is the maintenance of good physical condition, favorable biological activity, a suitable soil reaction, and an adequate supply of available plant-food elements during the growing season. The chief practices which accomplish these ends are—

1. Adequate drainage
2. Protection from erosion
3. Application of limestone where necessary
4. A good cropping system, including suitable legumes for soil improvement
5. Provision for active organic matter by returning regularly animal and plant manures
6. Purchase of mineral plant-food elements to supply deficiencies

PROVIDING ADEQUATE DRAINAGE

Adequate drainage is recognized as essential for the consistent production of satisfactory crops. Crops vary, however, in their ability to endure poor drainage. Alsike clover, for example, is better adapted to wet land than is red clover. Some bottom lands produce excellent summer crops but cannot be used for winter crops because of flooding. Altho such lands may not be well drained, it is often possible to raise good crops of corn on them year after year, because, as a result of frequent overflow, they receive periodically a fresh deposit of soil material. Such a practice on poorly drained upland would not be feasible. Upland soils, with few if any exceptions, require a well-planned cropping system if they are to be utilized most efficiently, and such a system is difficult to follow unless adequate drainage is provided.

Soils differ in permeability and consequently in their response to the installation of tile. There are soils in the southern and southwestern parts of Illinois, occupying a large total area, which cannot be drained successfully with tile because they have an impervious, clay-pan subsoil. In the east-central part of the state there is a soil occupying a considerable area which does not underdrain well because of an impervious glacial drift which comes to within 30 inches or less of the surface.

The soils of Illinois may well be artificially underdrained with the exception of those noted above. The soils which cannot be underdrained must be drained by means of open ditches and furrows or by means of a combination of open ditches, furrows, and tile provided with manholes thru which the water may enter the tile. In some soils the efficiency of the tile may be greatly increased by starting to fill the tile ditches with top-soil instead of with the more impervious material taken from the bottom of the ditches.

There are some soils in Illinois that cannot be satisfactorily drained either by tile or by open ditches. There should be no attempt to utilize such soils for general farming purposes.

PROTECTING SOIL FROM EROSION

The erosion problem is a serious one in Illinois. We are accustomed to think of erosion as being harmful only on rough and strongly rolling land. This seems, however, to be far from the truth.

The land surface subject to erosion in Illinois might be considered to include three groups of soils based on steepness of slope. The first group might be characterized as being subject to destructive erosion. Land of this character is located, for the most part, adjacent to streams and comprizes a total area in the state of some 7,000 square miles. Land subject to destructive erosion, is for the most part unsuited to general farming. If used for this purpose, erosion is so difficult to control that the returns do not justify the expense involved. Some of the land of this character may be used for orcharding and some of it may be used for permanent pasture but a large proportion of it is suitable only for timber.

A second group of erodible soils may be considered to include land suitable, under proper protection, for permanent pasture and orcharding but unsuited to general farming because of the steepness of the slopes resulting in destructive erosion if tilled. Land of this general character includes some 8,000 square miles. Terracing is recommendable on land of this character as affording a relatively inexpensive and an effective means of reducing erosion. There will be times however when erosion will be severe on land of this general character even on fields where the best known methods of control are being used.

Generally speaking the two groups mentioned above comprize land of relatively low agricultural value, as this term is commonly understood. If, however, certain of these soils are used for purposes for which they are adapted, they may be of considerable or, in some cases, of high value.

A third group comprizes the gently rolling to rolling land thruout the northern two-thirds of the state. Some 25,000 square miles may be included in this group. This land has a high value for general farming but is subject to harmful erosion and much of it is being seriously damaged thru the removal of surface soil by running water. The erosion problem presented by this third group is probably of more serious concern than that presented by either of the other two because of the high value of the land involved. Erosion can be controlled on a large proportion of this land by means of a good cropping system. Provision should be made for a protecting cover of vegetation particularly in the fall and spring. Cornstalks rolled down at a right angle to the slope are very effective in

FIG. 9.—PROPER SOIL TREATMENT AND CROPPING WOULD HAVE PREVENTED THIS CONDITION
This abandoned hillside is just over the fence from the field shown in Fig. 10.

reducing erosion on this gently sloping land. Long shallow draws may often be kept in permanent sod to great advantage. Broad base terraces may be effectively used where the slope is a little too steep for effective control to be secured with a good cropping system only. It is surprising however how effective a good cropping system is in decreasing washing. Experimental results indicate that on relatively gentle slopes of about 4 percent the surface seven inches of soil may be washed off in about twenty-five years where a poor cropping system is used, and that the use of a good cropping system alone will extend the time for the removal of the same amount of soil to some 350 years.

The method or combination of methods suitable for the control of erosion on any given area depends on many factors; that is to say, no generally applicable,

FIG. 10.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD
This land had formerly been badly eroded. It was reclaimed by proper soil treatment and cropping. Compare with Fig. 9.

detailed directions for controlling erosion can be given because such important factors as steepness of slope, length of slope, and permeability of the soil must be taken into consideration.

A detailed discussion of methods of controlling erosion will be found in Bulletin 207, "Washing of Soils and Methods of Prevention," and Circular 290, "Saving Soil by Use of Mangum Terraces," published by this Station.

APPLYING LIMESTONE TO CORRECT ACIDITY

The maintenance of a favorable soil reaction has been mentioned as one of the essentials in a rational system of soil management, and in contemplating a soil-improvement program one of the first steps for consideration is the application of limestone.

In considering the use of limestone it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides calcium, a plant-food element for which certain crops have a high requirement. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial bacteria. It plays an essential role in the chemical transformation of nitrogen. It helps to check the growth of certain fungous diseases, such as corn root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Most important of all its properties is its power to neutralize soil acidity, thus making possible thru the growing of legumes the reclamation of millions of unproductive acres as well as the improvement of land of moderate or even high productive capacity.

Soils vary tremendously with respect to acidity, and the question arises as to how the farmer is to know whether his land needs limestone. Much information on this subject, as it pertains to Illinois land, is to be found in connection with the soil survey. Some soil types are uniformly acid, and therefore in their description attention is called to the necessity of applying limestone; other types being alkaline thruout, do not need lime, and in the discussion this fact is recorded. There are, however, extensive soil types in which the lime requirement is not uniform. It may vary from field to field on the same farm. It may even change on a given field with the passing of time, especially under heavy cropping. Obviously in such cases a definite recommendation in regard to liming cannot be given, and under these circumstances the farmer is advised to resort to a test which he himself can learn to make.

Any citizen of the state may obtain from the county farm adviser or from the Experiment Station instructions for making a systematic limestone map of his fields, showing not only the areas that need liming but also approximately the amount of limestone to apply. Such a test made on soils where the lime requirement is decidedly variable is saving many hundreds of dollars in expenditures for limestone where limestone is not needed, as well as preventing the waste of clover seed on soils too acid to grow clover. For a description of this test see Circular 346 of this Station, "Test Your Soil for Acidity."

A good indication as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover. This crop does not thrive on acid soils and its thrifty growth therefore indicates that the soil is not acid, at least in a harmful degree. Some legumes, for example red clover, will grow fairly well on soil of moderate acidity provided conditions are otherwise favorable. Too much reliance therefore should not be placed on the behavior of

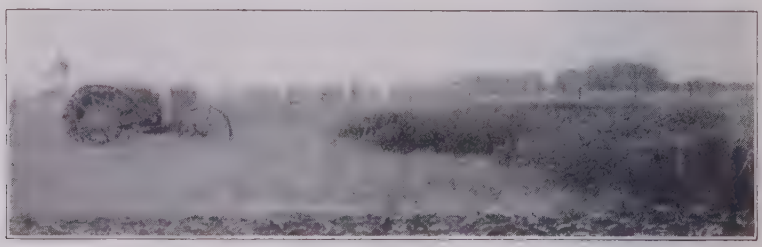

FIG. 11.—SWEET CLOVER AS AN INDICATOR OF THE NEED FOR LIMESTONE

Left, no limestone; right, limestone. Sweet clover is one of the most sensitive crops to soil acidity. This crop will not grow on acid soils until limestone has been applied.

legumes as an indicator of the need of liming, for it frequently happens that fair stands are mistaken for good stands and even good yields can often be greatly increased by the use of limestone. Therefore it is well to be definitely informed regarding the condition of the soil with respect to acidity, using, where necessary, a reliable test such as that mentioned above.

MAINTAINING A WELL-PLANNED CROP ROTATION

In any program of permanent soil improvement one should adopt at the outset a good system of crop rotation, including a liberal use of legumes. It is impossible to prescribe the best rotation for every individual case because what will prove to be the most advantageous system to follow depends upon a number of different factors. Of primary importance among these factors is the location of the farm with respect to soil, to climate, and to market. The particular rotation to be followed will be determined further by the type of farming—whether grain, livestock, orcharding, or other kind of enterprise. Finally, not the least important to be considered are the personal interests and inclinations of the farmer himself.

Following are a few suggested rotations, applicable mainly to the corn belt, which are intended to serve merely as patterns or outlines, to be modified according to special circumstances. In these suggested rotation programs the more common crops are mentioned merely as types, for which other crops of similar nature may be substituted as desired. In the following lists, for example, oats may be replaced by barley or spring wheat, and likewise winter rye might take the place of winter wheat. Or it may be advisable in some cases to divide the acreage of small grain and raise different kinds; for example, plant a part of the land to oats and a part to barley. The word "clover" in the following lists of rotations is used in a general sense to designate red, alsike, or sweet clover, or even a clover-grass mixture to serve either as pasture or meadow. In the event

of clover failure soybeans may be substituted. The value of sweet clover, especially as a green manure, for building up depleted soils is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized. In the following lists the word "clover" in parentheses signifies that clover is seeded in the grain crop.

Numberless different cropping systems might be enumerated, ranging thru various long-term and short-term rotations, but it will suffice for the present purpose to mention only a few systems as suggestive of types of rotations.

Six-Year Rotations

Among the longer type of rotations the following six-year systems are suggested as being good practical rotations adaptable under many circumstances. Two such programs are presented, one in which corn predominates and the other in which wheat is the major crop. Following are the crop sequences:

System A	*System B*
Corn	Corn
Corn	Oats
Oats (clover)	Wheat (clover)
Clover	Clover
Wheat (clover)	Wheat (clover)
Clover	Clover

In grain farming most of the crop residues are returned to the soil and the clover may be left on the land or returned after threshing out the seed. In livestock farming the clover may be mixed with alfalfa or with timothy, the crop being used for pasture or for meadow as desired. Soybeans, a crop that is rapidly coming into favor, can be introduced into System A by replacing either the first or the second corn crop or the last clover crop. In System B perhaps the best place for soybeans would be following the second wheat crop, altho it is possible to grow them in place of the oats.

An objection sometimes arises to wheat following clover on account of the wheat lodging. This lodging is not so likely to happen when the clover is cut as hay and removed from the land.

Five-Year Rotations

A five-year rotation system offers one of the most convenient cropping plans that can be devised for general farming. It is flexible, it provides diversification, and it can be made to give large place to legumes. Here again two different basal systems are presented, one designed primarily for corn as the major crop and the other for wheat:

System C	*System D*
Corn	Corn
Corn	Oats
Oats (clover)	Wheat (clover)
Clover	Clover
Wheat (clover)	Wheat (clover)

It is of interest to observe that if soybeans were to replace second-year corn in System C or oats in System D, and the clover catch crop were allowed to grow a while in the spring before corn planting, then a legume crop would appear on every acre every year.

Four-Year Rotations

The four-year rotation represents a rather common cropping system. Among the several possibilities the following are suggested as practical programs for a four-year rotation:

System E	*System F*
Corn	Corn
Corn	Oats (clover)
Oats (clover)	Wheat (clover)
Clover	Clover

System E which calls for half the land to be in corn, requires a productive soil. However, half the land is under legumes and this is also true of System F. Soybeans might take the place of one of the corn crops in System E. In System F they might take the place of the oats provided the bean crop is removed early in order to make way for the fall seeding of the wheat.

Three-Year Rotations

One of the most common rotations practiced in the corn belt is the three-year crop succession of corn, oats, and clover (System G). From the standpoint of soil maintenance this is a good rotation. Legumes appear on the land two years out of three. It is also advantageous from the standpoint of labor economy, for plowing is required only once in three years. Its main disadvantage perhaps lies in the restricted crop diversification.

System G	*System H*
Corn	Wheat (clover)
Oats (clover)	Corn
Clover	Soybeans

An opportunity to introduce wheat into a three-year cropping plan is offered in System H. It is of interest to note that by seeding a catch crop of sweet clover in the wheat, to be plowed under the following spring just before corn planting, the land is under legumes some portion of the season every year. It will be necessary to harvest the soybeans early either by using an early variety or by cutting for hay in order to prepare the land for winter wheat. In some regions it may be desirable to substitute cowpeas for the soybeans.

Two-Year Rotation

The well-known practice of alternating corn and oats has long been pointed out as an example of a bad rotation under which thousands of corn-belt farms are headed toward ruination. However, with the advent of sweet clover, that great soil restorer, a corn-oats rotation becomes a practical possibility.

System I
Corn
Oats (sweet clover)

In this system sweet clover is sown in the oats, pastured in the fall and the following spring if desired, and then plowed down in preparation for corn. From the standpoint of soil upkeep, this cropping plan, which may fit well in certain situations, is offered as an interesting possibility, altho from the general

farm-management point of view it may lack some of the advantages of the longer rotations described above.

Altho oats are mentioned as the spring grain crop, as a matter of fact by dividing the land devoted to small grain and introducing barley, these two crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

Alfalfa and Pasture in Rotation

Alfalfa is a highly desirable crop to grow, especially in livestock farming. Its possible use as a biennial legume in the rotation has already been pointed out. It is often desirable, however, to include alfalfa as a perennial stand in the cropping system. This can be done by providing one extra field. The alfalfa occupies a field during a complete rotation period of the other crops plus one year extra. The alfalfa is then shifted to another field while the other crops rotate, and so on around the entire field system.

It may be observed that this same plan for alfalfa in rotation will provide for continuous pasture of any kind, either of perennial grass or of grass and clover mixture.

SUPPLYING RIGHT KINDS AND AMOUNTS OF ORGANIC MATTER

Organic matter acts beneficially chiefly in two ways: it helps to maintain favorable physical conditions in the soil; and it supplies food material for the microscopic organisms which inhabit the soil and which in turn, thru their life processes, effect many of the necessary chemical transformations that render plant food available for the growing crops.

The main sources of supply for organic matter are stable manure, crop residues, and green manures.

A recent study of the results from the soil experiment fields located in many different parts of Illinois reveals the fact that the system of treatment that has most frequently returned the greatest profit is manure with limestone. Of the eight systems compared, this proved to be the winning treatment on more than 60 percent of the fields. This indicates the very great value of stable manure and suggests the importance of its careful conservation and use on every farm where this material is available. On most farms, however, there is not sufficient animal manure produced to cover the land, and thus it becomes necessary to resort to some other supply of organic matter. The alternative here lies in the so-called "crop-residues" system, in which unused materials such as stalks, straw, and chaff are returned to the land and plowed under along with leguminous green-manure crops.

In connection with the application of organic matter, an important distinction between kinds of organic matter with respect to chemical make-up has come to be recognized within the last few years. It is commonly observed that an excessive application of straw or similar material is likely to produce a depression in crop growth which may result in lowering the yield. In addition to the unfavorable physical effect of plowing down a mass of decay-resistant material, particularly if dry weather ensues, a detrimental chemical effect may also follow.

The large quantity of cellulose contained in straw stimulates the activities of a certain set of microscopic organisms. These may become so active as actually to compete with the growing plants for nitrate and so under certain circumstances to cause nitrogen hunger. Good judgment must therefore be exercised in applying strawy material. Heavy applications should ordinarily be avoided unless they can be plowed under with a good growth of legumes or else applied at such a time as not to interfere with a crop having a large nitrate requirement.

MINERAL PLANT-FOOD REQUIREMENTS AND SUPPLY

Ten chemical elements have long been accepted as being essential for the growth of the higher plants. These are carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium, and iron. To this list certain other elements have been added from time to time as being either necessary in the physiological processes or else present merely on account of absorption from the soil solution.

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the elements obtained from the soil by all plants, may also be secured indirectly from the air by the class of plants known as legumes, in case the amount liberated from the soil is insufficient.

Table 10 shows the average content of some of our most common field crops with respect to seven important plant-food elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of an element removed from an acre of land by a crop of a given yield can easily be computed.

TABLE 10.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil. In presenting these figures it is not intended to imply that plants are restricted in their feeding to the surface stratum, nor that the total quantities of the various plant-food elements give a reliable indication of the immediate fertilizer requirements of a soil except in extreme cases. Such extreme cases, however, are relatively rare and there are the great middle classes in which chemical composition varies so little as to furnish no clue whatever to the probable effect of a particular fertilizer treatment. Much depends upon the ability of the crops grown to utilize plant-food material, and much depends upon the solubility of the plant-food substances themselves. When an element becomes so reduced, either in total quantity or in available form, as to become a limiting factor of production, then we must look for some outside source of supply. Table 11 shows the approximate quantities of some of the more important plant-food elements contained in materials most commonly used as fertilizers.

TABLE 11.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Superphosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

[1]See footnote to Table 10. [2]Young second-year growth ready to plow under as green manure. [3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

FIG. 12.—ALL ESSENTIAL PLANT-FOOD ELEMENTS MUST BE PRESENT

The jars in which these corn plants are growing contain pure sand to which have been added various combinations of the essential plant-food elements. If a single one of these elements is omitted, the plants cannot develop; they die after the small supply stored in the seed becomes exhausted.

Nitrogen Problem

The nitrogen problem is one of foremost importance in American agriculture. There are four reasons for this: nitrogen is becoming increasingly deficient in most soils; its cost, when purchased on the open market, is often prohibitive; it is removed from the soil in large amounts by crops; and it is readily lost from soils by leaching. A 50-bushel crop of corn requires about 75 pounds of nitrogen for its growth; and the loss of nitrogen from soils by leaching may vary from a few pounds to over one hundred pounds an acre in a year, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about 69 million pounds of atmospheric nitrogen. Leguminous plants such as the clovers are able, with the aid of certain bacteria, to draw upon this supply of air nitrogen, utilizing it in their food requirements. In so doing, these leguminous plants if returned to the land add to the soil a part of the nitrogen which has been taken from the air and transformed into food material that can be assimilated by other kinds of crops that follow. By taking advantage of this fact and introducing periodically into the rotation system a crop of legumes, the farmer may draw upon this cheapest source of nitrogen for soil improvement. In general farming, therefore, that is, in the production of such crops as corn, oats, wheat, and hay, legumes should furnish the main stock of nitrogen, this stock to be supplemented, of course, by all available manure and by other farm waste materials containing nitrogen.

In addition to these home sources of nitrogen supply, there are various commercial products containing nitrogen offered on the market. These materials

FIG. 13.—LEGUMES CAN OBTAIN THEIR NITROGEN FROM THE AIR

The photograph tells the story of how clover benefits the soil. In the pot at the left all the essential plant-food elements, including nitrogen, are supplied. In the middle jar all the elements, with the single exception of nitrogen, are present. At the right nitrogen is likewise withheld but the proper bacteria are supplied which enable the clover to secure nitrogen from the air.

formerly consisted largely of sodium nitrate, a mineral imported from South America; ammonium sulfate, produced in the manufacture of coal gas and coke; and certain waste and by-product materials mainly of organic composition. Within very recent time, however, tremendous developments in the synthetic production of nitrogen compounds from air nitrogen have taken place. Among these new fertilizer materials may be mentioned cyanamid, calcium nitrate, sodium nitrate, ammonium nitrate, and urea.

These developments in the artificial fixation of nitrogen will doubtless have a far-reaching effect in reducing the cost of commercial nitrogenous fertilizers. What the limits may be in this direction one dare not predict. Whether these manufactured nitrogen compounds will become so cheap some day as actually to compete with legume nitrogen is problematical, especially when the other advantages offered by legumes are considered. However, the day has not yet arrived when we can afford to dispense with legumes as a green manuring crop in the production of grain and hay.

Accepting, then, this principle that legumes and farm wastes must constitute the main source of nitrogen supply, the question arises—can these home-grown materials be supplemented to advantage by the use of commercial carriers of nitrogen?

The impossibility of making blanket recommendations has already been pointed out. The question finally resolves itself into a matter of expense and profit for each individual case. Sodium nitrate is purchased on the market at present at about $65 a ton. If a farmer applies 100 pounds an acre, he provides about two-fifths of an ounce to a hill of corn. A ton would cover 20 acres and the cost would be about $3.25 an acre. Under present prices an increase of about four to five bushels of corn or wheat would be required in order to cover the cost before any profit could be realized.

Under what circumstances might such increases in yield be reasonably expected? It is possible that in many cases where manure or legumes have not been used, such an application of nitrogen would return a profit, but such usage should be regarded as a temporary expedient rather than a permanent practice

in soil management. Under adverse weather conditions, when soil nitrates are formed too slowly or are washed away by excessive rain, an application of nitrogen fertilizer may prove highly beneficial to wheat and corn.

A peculiar hazard accompanies the application of nitrogen that does not obtain in applying phosphate or potash. Nitrates are readily washed away, and if circumstances are such that the first crop fails to utilize the nitrogen, little or no residual effect on the following crops can be expected. For this reason special caution should be used against applying excessive amounts of nitrogen. Usually it is well to divide the application of a quickly soluble nitrogen fertilizer such as sodium nitrate, using a portion at planting time and distributing the remainder at a later date. Nitrogenous fertilizers are often made up of a mixture of materials whose nitrogen becomes soluble with varying degrees of rapidity, thus automatically distributing the action of the nitrogen over a period of time.

Phosphorus Problem

Different soil types display great variation in phosphorus content and, on the other hand, soils of like total-phosphorus content exhibit great variation in response to phosphate fertilization. The removal of phosphorus by continuous cropping slowly reduces the amount of this element available for crop use unless its addition is provided for by natural means such as overflow, or by agricultural practices such as the addition of farm manure and phosphatic fertilizers and perhaps the use of rotations in which deep-rooting leguminous crops are frequently grown. Results obtained from the soil experiment fields of Illinois show that some soils respond highly to phosphate fertilization, while others give a very low response or none. Reports from county farm advisers and farmers in general are in agreement with these experimental results.

As stated above, the total quantity of phosphorus present in a soil is not a reliable indicator of the probable response to phosphate fertilization. Apparently it is a matter of solubility or the chemical form in which the phosphorus exists rather than total quantity.

A simple field test has recently been devised at the Illinois Experiment Station which will distinguish soils having a high amount of available phosphorus from those having a low amount. Information concerning this test is furnished in Bulletin 337, "A Field Test for Available Phosphorus in Soils."

There are several different phosphorus-containing materials that are used as fertilizers. The more important of these are rock phosphate and superphosphate. Other valuable carriers of phosphorus are bone meal and basic slag.

Rock phosphate is a mineral substance found in vast deposits in certain regions. A good grade of the rock should contain 12 to 15 percent of the phosphorus element. The rock should be ground to a powder fine enough to pass thru a 100-mesh sieve, or even finer. Considerable experimentation in the finer grinding is under way in the hope of increasing the plant-food value of the product and thus make possible a reduction in the amount that it is necessary to apply.

Superphosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. By further

processing, different concentrations are produced. The most common grades of superphosphate now on the market contain 7, 8¾, and 10½ percent of the element phosphorus, and even more highly concentrated products containing as high as 21 percent are to be had. In fertilizer literature the term phosphorus is usually expressed as "phosphoric acid" (P_2O_5) rather than the element phosphorus (P), and the chemical relation between the two is such as to make the above figures correspond to 16, 20, 24, and 48 percent of phosphoric acid respectively. Likewise the 12 to 15 percent of phosphorus in rock phosphate corresponds to 29.5 to 34.3 percent of phosphoric acid. Besides phosphorus, superphosphate also contains sulfur, which is likewise an element of plant food, altho this fact has little agricultural significance for Illinois, where the soils generally are sufficiently stocked with sulfur. In general, phosphorus in superphosphate is considered to be more readily available for absorption by plants than is the phosphorus in raw rock phosphate, altho there is often good response in the crops immediately following the application of rock phosphate.

Obviously the carrier of phosphorus that will give the most profitable returns, considered from all standpoints, is the one to use. The question of which is the most profitable, however, remains unsettled, altho it has been the subject of much discussion and investigation. The fact probably is that there is no single carrier that will prove the most economical under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

The relative cheapness of raw rock phosphate as compared with the treated material, superphosphate, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in the form of rock than in the form of superphosphate, the ratio being, under present market conditions, roughly speaking 3½ to 1; that is to say, a dollar will purchase about three and a half times as much of the phosphorus element in the form of rock phosphate as in the form of superphosphate, and this is an important consideration if one is interested in building up a phosphorus reserve in the soil.

On several of the Illinois soil experiment fields rock phosphate and superphosphate are being compared in systems of management looking toward permanent soil improvement, and are applied in amounts corresponding approximately to equivalent money expenditures. So far as these comparisons show, there appears to be little consistency in the results. In some years and on some crops superphosphate has furnished the greater profit; in other years and on other crops the reverse is true. In some cases neither material has paid for its cost, indicating that phosphorus is not a limiting factor in production on all soils. On the whole, therefore, if possible residual effects are disregarded, there appears to be no indisputable evidence for general discrimination between the two forms of phosphate.

Potassium Problem

Our most common soils, the silt loams and clay loams, are well stocked with potassium altho it exists mainly in a very slowly soluble form and probably only a very small percentage of the total potassium exists in a form available to plants at any one time.

Many field experiments in various sections of Illinois during the past twenty-five years have shown little or no response to the application of potassium in the production of our common grain and hay crops. On the light-colored soils of southern Illinois, however, where stable manure has not been employed, potassium has been applied with profit, the benefit appearing mainly in the corn crop.

Peat soils usually respond to potash fertilization. The Illinois Experiment Station has demonstrated in field experiments located on peat land that the difference between success and failure in raising crops on such land depends upon the application of a potash fertilizer.

Potassium has proved beneficial also on the so-called "alkali" spots occurring on certin soil types that are rather high in organic matter, including peat and dark-colored sandy, silt, and clay loams. The unproductiveness of these soils is probably due largely to the unavailable condition of the soil potassium as well as to an unbalanced condition of the plant nutrients resulting from an excess of nitrate nitrogen. The addition of potash has a beneficial influence upon both of these unfavorable conditions.

Potash fertilizer may be procured in the form of one of the potassium salts, such as the chlorid, sulfate, or carbonate, and any of these materials may be applied, where needed, at the rate of 50 to 150 pounds an acre according to the method of distribution. For our most common crops about the only basis for choosing among these forms is the matter of price, taking into consideration the potassium content.

Kainit is another substance containing potassium, but it is combined with magnesium in the form of a double salt. It is therefore less concentrated than the salts mentioned above, and so should be applied in larger quantities. An application of about 200 pounds or more of kainit to the acre is suggested.

Use of Mixed Commercial Fertilizers

A mixed commercial fertilizer is a combination of substances containing either two or three of the plant-food elements nitrogen, phosphorus, and potassium. If the material contains all three of these elements, it is said to be a "complete" mixed fertilizer; if only two of the three are present, it is said to be an "incomplete" mixed fertilizer.

A complete mixed fertilizer has the general formula $N–P_2O_5–K_2O$ (nitrogen, phosphorus pentoxid, potassium oxid), the proportions of the elements varying according to the way in which the material is compounded. By substituting figures for the letters in this formula the percentage composition of the fertilizer is indicated. Thus a fertilizer of the formula 5-15-5 contains 5 percent nitrogen, 15 percent phosphorus pentoxid (usually designated as phosphoric acid), and 5 per cent potassium oxid (usually called potash). Translated into pounds, this means that a ton of the fertilizer contains 100 pounds of nitrogen, 300 pounds of phosphoric acid, and 100 pounds of potash. For the benefit of those who are accustomed to think in terms of the simple plant-food elements rather than these combinations, it may be explained that the above amounts correspond to 100 pounds of the element nitrogen (N), 131 pounds of the element phosphorus

(P), and 83 pounds of the element potassium (K). Changing the formula to read 0-15-5 indicates that no nitrogen is contained in it; 5-15-0 means that no potassium is present; and 5-0-5 indicates that phosphorus is absent.

In compounding these fertilizers, several ingredients carrying a single kind of plant-food element may be used. For example, a portion of the total nitrogen may be furnished by sodium nitrate, while another portion may be carried in dried blood or in ammonium sulfate. In addition to these plant-food materials, fillers and conditioners are often used in such amounts as to make the finished product contain the desired percentage of plant food.

A distinction between what are considered "high-grade" and "low-grade" fertilizers is now being made upon the arbitrary basis of a total of 16 so-called "units of plant food." Thus a 2-8-2 fertilizer carrying 12 units of plant-food would classify as a low-analysis grade. The advantage of using the higher grade products is becoming more and more generally recognized by both consumers and producers of fertilizers. In the latest developments still more concentrated forms of fertilizers are being produced containing as much as 60 units of plant food. If the economy of production and the agricultural value justify the general use of materials of such high concentration, there should be a great saving in the cost of transportation and handling thru the use of fertilizers of this type.

The question arises repeatedly regarding the employment of mixed commercial fertilizers, and particularly their employment in connection with a basic program of soil improvement built around the use of legumes and limestone where necessary.

An important principle to be borne in mind in the use of any fertilizer is represented in the so-called "law of the minimum," that is, that no benefit can result from the application of a given plant-food element unless the need for that element is a limiting factor in plant growth. If, for example, there is already in the soil enough available phosphorus to produce a 40-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only 40 bushels or less, all the phosphorus one might apply would be absolutely ineffective in increasing the yield beyond this 40-bushel limit.

The most serious objection to the indiscriminate use of mixed commercial fertilizers lies in the fact that frequently only one, or perhaps two, of the plant-food elements carried by the fertilizer are actually needed, in which case a useless expense is incurred for the unnecessary element or elements.

This question of the use of commercial fertilizers is exceedingly complicated because so much depends upon numberless conditions of soil and season. We may be able to analyze in part the conditions of the soil, but we are powerless in predicting the conditions of the oncoming season. A given fertilizer may pay a handsome profit this season but on the same field next year may be absolutely without effect, or even detrimental to the crop. That is why it is impossible to make any general statement or to give a blanket recommendation concerning the use of such fertilizers.

The matter finally resolves itself into two questions: cost of material and benefit derived. Fortunately the cost of material can be definitely determined.

In order to get an idea of the expense of applying mixed commercial fertilizers, perhaps we cannot do better than to figure the cost per acre based upon the published recommendations and price quotations of a fertilizer company. The following estimates are based upon the recommendations of such a company as given for the dark-colored silt or clay loam soils of Illinois on land having had manure and clover, and the prices are those quoted for the spring of 1929.

Thus, for the corn crop, 150 pounds per acre of a 5-15-5 fertilizer is recommended to be applied in drills or hill-dropped. The price of this fertilizer is quoted at $53.15 a ton, which would make the cost $3.99 per acre. According to an official report, the farm value of corn for December, 1928, in Illinois was 70 cents a bushel. At this rate an increase of 5.7 bushels of corn per acre would be required to cover the cost of the fertilizer, taking no account of the extra expense in applying it.

For spring grains the recommendation is to use a 0-21-9 fertilizer at the rate of 250 pounds an acre if drilled or 400 pounds if broadcast. The price is $45.10 a ton, thus making the cost per acre $5.64 drilled or $9.02 broadcast. If the spring grain were oats, valued at 38 cents a bushel, the increase in yield to cover the cost of fertilizer would have to be nearly 15 bushels an acre in the case the fertilizer were drilled; if it were broadcast nearly 24 bushels would be required to pay the cost before any profit would be realized. If instead of oats the spring grain were wheat valued at $1.02 a bushel, the increase in yield necessary to pay for the fertilizer would be 5½ bushels if the fertilizer were drilled and nearly 9 bushels if broadcast. In like manner the recommended application for potatoes is found to cost $13.13 an acre if the fertilizer is drilled and $26.25 if broadcast. The application recommended for pastures and meadows would cost $13.13 an acre.

The above examples afford some idea of the cost of using mixed commercial fertilizers for the production of our common field crops in so far as the prices quoted remain representative. Unfortunately it is impossible to furnish information with the same certainty concerning the profit that is likely to be derived from these fertilizers, for that will depend upon several varying factors, mainly the amount of increase in yield and the price received for it.

What kind of fertilizers will be profitable and under what particular conditions they will pay must be determined mainly on the basis of actual experience. In this connection it should be borne in mind that in all experimental trials great care must be exercised in drawing conclusions. The soil of a farm or even of a field is seldom perfectly uniform throuout, and differences in yield really due to differences in soil may easily be mistaken for effects of the fertilizer treatment. Therefore small differences in yield should be critically considered before being accepted as significant. It is particularly risky to base conclusions upon the results of a single year, because of peculiar seasonal effects. Never are two seasons exactly alike, and the results of this year may not apply next year. If outstanding effects from fertilizers occur the first year they are tried, such results may be taken as indicative and accepted as a tentative guide for further work,

but final conclusions should be withheld until these results are well confirmed in subsequent trials.

To what extent mixed commercial fertilizers can be profitably employed in connection with a basic program of soil improvement is a problem of great consequence. No doubt there are many instances in which such fertilizers may be used with profit, but it is just as certain that in many other instances their use would result in financial loss. Before investing in mixed fertilizers, farmers should carefully consider the cost, which, as explained above, is an item that can be definitely determined. With the investigations now under way, the Experiment Station hopes soon to be in possession of much more definite information than now exists regarding the use, under present-day conditions, of these mixed commercial fertilizers.

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